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A

# D I C T I O N A R Y

O F

## C H E M I S T R Y.

A C I

- I. **A**BSORBENT. (*a*)  
II. **A**CETOUS. (*b*)  
III. **A**CESCENT.

This word may be employed to denote a matter, which either is turning sour, that is to say, acid, or which is slightly acid. See ACID. (*c*)

IV. A C I D. Acids are of all saline substances the most simple, and consequently ought to be considered as *secondary principles*. Their name is derived from their taste, which is acid or sour. One of the marks by which they are easily known, is their property of changing into red the blue colors of an infusion of flowers of violets, or of the tincture of heliotropium. (*d*)

If acids were separated from all moisture or water, and from all other substances not necessary to their saline essence, they would appear under a concrete

(*a*) **A**BSORBENT. Those *earths* are called *absorbent*, which are capable of being combined with acids. These are calcareous earths, ashes of burnt vegetable and animal substances, magnesia, and earth of alum. This class of earths might be more properly denominated *alkaline earths*. See EARTH, MAGNESIA, ALUM.

(*b*) **A**CETOUS. *Acetous acid* is the same as vinegar. *Acetous fermentation* is that fermentation by which vinegar is produced. *Acetous ether* is an ether made by means of vinegar. See VINEGAR, and ETHER.

(*c*) The word *acid* can only be properly applied to denote the first of these meanings. The second may be expressed by either of the words, *acidulous* or *subacid*.

(*d*) This property of changing the blue, and of heightening the red colors of vegetables, is not common to all acids, for the volatile sulphureous acid destroys these colors: nor is it peculiar to acids; for alum, a neutral salt, produces the same effect.

or solid form. But generally they are liquid ; because their affinity to water is so great, that when they contain no more than what is necessary to constitute them salts, they are strongly disposed to seize more water, whenever they can touch it ; and as the atmosphere is always loaded with watery vapors, the contact of the air is solely sufficient to render acids fluid, by their rapid union with its moisture.

Acids have a general tendency to unite with almost all substances, particularly with those which are either simple, or not much compounded ; as phlogiston, alkaline salts, fixed and volatile, earths, (especially those called *absorbent*), metallic substances, water, and oil.

Many substances are by chemists called *acids*, because they possess those general properties which we have mentioned. But these substances differ from each other by properties peculiar to each.

As acids from their tendency to unite, and to remain united with almost all other bodies, are never found single and pure, but must be obtained and separated by artificial operations from the bodies with which they happen to be combined ; they have been distinguished by authors into classes, according to the substances whence they are extracted. These classes are *mineral acids*, *vegetable acids*, and *animal acids*. In Mr. Geoffroy's Table of Affinities, those of acids are marked in the following order : fixed alkali ; volatile alkali ; earths ; metallic substances. (e)

Very concentrated acids taken internally in a dose somewhat large ; for instance, an ounce, or even much less, when the acid is susceptible of great concentration ; are corrosive and genuine poisons. Their best antidotes are alkaline substances, either saline or earthy, oils, alkaline soaps, large quantities of mild drink, as water, milk, mucilages. These must be given copiously and speedily.

Small doses of acids diluted with much water, so as to be agreeably acidulous, and blunted by some mild substance, as sugar, are excellent cooling and aperitive medicines, fit to quench excessive thirst, and lessen the acrimony of the bile. They are chiefly useful in alkalescent dispositions, and in putrid, inflammatory fevers. Their whole action seems to be exerted on the primæ viæ ; for they are rendered inactive by the powers of digestion, by means of which they are combined with the earthy and oily parts of aliments and digestive juices. They would be certain poisons if they passed into the blood vessels with their acid qualities, at least with their acidity undiminished. They would coagulate the blood, and would greatly irritate the nervous and sensible parts. Malpighi killed a dog by injecting into the veins such a quantity of nitrous acid, as would not have hurt, if it had been swallowed. Acids employed externally shew similar qualities, but more sensibly than when impaired by the digestive powers. They are useful against alkalescent putridity. (f)

(e) The *affinities or powers of union of acids* are, 1. Fixed alkali ; 2. Calcareous earth ; 3. Volatile alkali, and magnesia, the powers of union of these two being nearly equal ; 4. Iron, zinc, copper, and perhaps some other metals ; 5. Earth of alum ; 6. The remaining metals.

(f) 1. The *common properties of acids* are, 1. They may be united with water. This is not merely a dilution of acids, for by uniting them with a certain quantity of water, heat or cold is produced, and the mixed fluid acquires a specific gravity, different from the inter-



**V. ACIDS (ANIMAL).** This name is given to acids obtained from certain animal matters ; as butter, fat, blood, ants, and most flies.

These acids have been too little examined to enable us to judge whether they be essentially different from those obtained from vegetables. But we are certain, that they differ in the same circumstances as the vegetable acids do from mineral acids ; and probably, this difference proceeds from the same cause

intermediate gravity of its component parts. From this union, therefore, a new compound is formed. 2. They may be combined with spirit of wine. *See ETHER.* 3. They may be combined with absorbent earths. 4. They may be combined with alkaline salts. 5. They may be combined with metallic substances. Although every acid does not directly dissolve every metallic substance, yet probably by concentration or dilution of the acid, division of the metals by mechanical and chemical methods, by application of sufficient heat, and other means, every metal may be acted upon by every acid. 6. They may be combined with phlogiston, and with oils. 7. When they combine with these substances, they disengage from them all or part of the fixable air which they contain. 8. They soften and dissolve the solid parts of animals. 9. They coagulate most of the liquid parts of animals. 10. They change to red the blue, and heighten the colors of vegetables, excepting volatile, sulphureous acid, which destroys these colors. Probably this change of color proceeds from the action of acids upon the oily parts of vegetables ; for oils are rendered red by sufficiently concentrated acids. 11. They resist fermentations. 12. They are not capable of being frozen by so small a degree of cold as water is. 13. They produce cold when poured upon ice.

2. As acids so powerfully attract water, that they are never found pure and dry, but always in a fluid state, when uncombined with earths, alkalies, or metals, we cannot easily ascertain the quantity of acid contained

in acid liquors. Homberg has attempted to estimate the quantity of acid contained in the acid spirits of vinegar, nitre, sea-salt, and of vitriol, by combining these liquors with salt of tartar, so as to form neutral salts ; imagining that the weight gained by that alkali from its union with acids, or the difference betwixt the weight of the salt of tartar and the neutral salt produced, was equal to the weight of real acid contained in the quantity of acid liquor employed. But as he did not consider, that the air expelled from salt of tartar, during its combination with acids, makes a very considerable part of the weight of that alkali, the inferences from his experiments are not just ; and the real quantity of acid contained in an acid liquor, is so much more than the quantity inferred by him, as the whole weight of the fixable air disengaged from the salt of tartar. The quantity of fixable air contained in salt of tartar varies much according to the method of its preparation, and other circumstances ; but if we suppose that the fixable air in the salt of tartar, used by Homberg, was in as great a proportion as in the pearl-ashes of Mr. Cavendish, [Phil Trans. 1766] that is  $\frac{1}{180}$  of the whole weight of the alkali, by adding  $\frac{1}{180}$  of the alkali used in each experiment, we shall nearly find the true quantity of solid acid in each neutral salt. The first column shews the quantity of each of the acids employed to saturate an ounce of salt of tartar ; and the second column shews the quantities of the neutral salts produced.

1.  
Distilled vinegar, 14 oz.  
Spirit of salt, oz. 2. dr. 5.  
Spirit of nitre, oz. 1. dr. 2. gr. 36.  
Acid of vitriol, dr. 5.

2.  
oz. 1. dr. 3. gr. 36.  
oz. 1. dr. 3. gr. 14.  
oz. 1. dr. 3. gr. 10.  
oz. 1. dr. 3. gr. 5.

Homberg supposes, that in each of the neutral salts, the quantities of which are mentioned in the second column, the quan-

tity of contained alkaline salt is equal to an ounce, and the quantity of contained acid is equal to the remaining weight ; whereas

by

which constitutes the difference betwixt the vegetable and mineral acids, namely, the combination of oily particles with the former. (g)

The *phosphoric acid*, obtained from urine, appears, for the same reason, to belong to this class of animal acids. But it has properties so different from those

by our proposed method of correction, supposing still that the quantity of fixable air in his salt of tartar was  $\frac{388}{1000}$  of the whole weight, we shall find that of the oz. 1. dr. 3. gr. 5. of vitriolated tartar in the last mentioned instance of the table, dr. 5. gr. 44. were fixed alkali deprived of its air, and dr. 5. gr. 21. were acid. Hence we may perceive that the quantities of alkali and of acid in the several neutral salts, the weights of which are expressed in the second column of the table, are very nearly equal. See AIR (FIXABLE.)

3. The known acids are, 1. Vitriolic acid. 2. Nitrous acid. 3. Marine acid. 4. Acetous acid. 5. Vinous acid, or tartar. 6. Essential acid of vegetables. 7. Acid obtained by distillation of vegetables. 8. Acid of bitumens. 9. Acid of borax. 10. Acid obtained by distillation of oils, resins, and fats. 11. Phosphoric acid. 12. Acid of ants and other insects. 13. Acids of healthy and of diseased stomachs of animals. 14. Acid of perspirable matter of diseased animals. Perhaps the number of acids is much larger; or perhaps some of these are only modifications of other primary acids; or lastly, as Stahl supposes, they are all modifications of the one only primary acid, namely, that of vitriol. See the theory of acids under the article SALT.

(g) The acid of ants may be perceived by smell, on turning up an ant-hill in spring or summer. When these insects are irritated, they discharge a fluid which has an acid taste and smell. Water, or spirit of wine, in which they are agitated, becomes acidulous. Part of this acid is so volatile as to rise by distillation with spirit of wine, in which ants had been immersed; but the greatest part of it is so fixed, as to remain united with the residuous phlegm. All the acid may be extracted by water, and rendered capable of rising by distillation with that fluid in a water-bath. From 24 ounces of fresh ants were obtained by distillation, without addition, eleven ounces and two

drams of acid spirit, some urinous salt and spirit, some empyreumatic oil, and a residuum, consisting of earth and fixed salt. This acid is found to have the general properties of acids. With fixed alkalies it forms neutral crystals, oblong, and deliquescent. These crystals being distilled by a violent fire, yielded a liquor scarcely acid, and another liquor urinous or ammoniacal. From the residuum dissolved in water, by filtration and evaporation, were obtained large crystals which did not deliquiate, and had the general properties of fixed alkalies. In this experiment the acid seemed to disappear. But by pouring oil of vitriol on these alkaline crystals, white vapors were disengaged, although no acid spirit could be obtained by distillation. From these white vapors; and from the facility with which this salt crystallizes, Mr. Margraaf, from whom these and the following experiments on the acid of ants are extracted, suspects the existence of a latent acid. The acid of ants formed with volatile alkali an ammoniacal fluid, which, like the combination of the same alkali with vinegar, could not be reduced to a concrete or solid state. With quicklime, chalk, and coral, it formed dry crystals.

This acid did not precipitate silver, lead, or mercury, from nitrous acid; hence it has no analogy to marine acid. Nor did it precipitate quicklime from marine acid; and hence it has no analogy to vitriolic acid.

As a menstruum, this acid acted weakly upon copper, and strongly upon iron and upon zinc; but it did not act, or very little, upon silver, lead, tin, regulus of antimony and bismuth. Its combination with iron crystallized; in which respect it differs from vinegar. It dissolved the calxes of copper, silver, zinc, and lead; but not the calxes of tin, regulus of antimony, bismuth, or of mercury, which last calx it converted to fluid quicksilver. Upon the whole (says Margraaf), we may perceive a resemblance in many respects, though not in all, betwixt this acid and the acetous. See the *Memoirs* of

of all other acids, that it deserves to be considered as a distinct acid. See PHOSPHORUS.

VI. ACIDS (CONCRETE). These are saline, solid substances which have the general properties of acids. Such are, *crystals of tartar*; *essential salts of vegetables*, particularly of those which are acid; the *volatile acid salt of amber*, and of some other *bitumens*; and *flowers of Benjamin*.

VII. ACID of VINEGAR. See VINEGAR.

VIII. ACIDS (FLUOR), Are those which are generally, or always in a fluid state; such are the volatile vitriolic, nitrous, marine acids, and those obtained by distillation from vegetable and animal substances.

IX. ACID (MARINE). This is so called, because it is generally obtained from sea-salt; though it may be also procured from *Sal-gem*, or *fossile salt*, and from the salt of saline fountains and pits, since all these salts are different from sea-salt, only as to their origin.

The marine acid, as well as the nitrous and vitriolic, is never found alone and pure; but it is always combined with an alkali, so as to form a neutral salt, which is dissolved copiously in the sea, to which it gives a salt taste.

This neutral salt is also found crystallized in large transparent masses within the earth, and is then called *Sal-gem*, or *fossile salt*.

It is also dissolved in the waters of some *wells* or *fountains*, which may be owing to these waters communicating by subterraneous passages with the sea, or to their passing through mines of *Sal-gem*.

The marine acid has all the general properties of saline acid substances.

*It differs from the vitriolic acid* in the following circumstances: it is more light and volatile; it has smell and color; it emits vapors; it has less affinity with fixed alkalies and absorbent earths; and, like the nitrous acid, it forms with absorbent earths no salts but such as are deliquescent.

*It differs from the nitrous acid* by its color, which is more yellow and less red; by the whiteness of its vapors, which are visible only in open air; by its smell, which resembles saffron; by a weaker affinity with absorbent earths and fixed alkalies. (b)

The marine acid cannot be so much concentrated as the vitriolic and nitrous acids, because it is more volatile.

This acid cannot be so easily combined with phlogiston as the vitriolic and nitrous, and we are not certain that some medium is not requisite for such a combination.

Although the properties of the marine acid are as well known as those of nitrous and vitriolic, yet chemists are far from understanding the nature of this saline substance equally well. Becker, according to his theory of acids, attributes the distinguishing properties of the marine acid to that principle which

*the Berlin Academy*, vol. 4. 1749, or the *Opus- cules Chimiques de Mr. Margraaf*.

*Insects* armed with stings, as bees, wasps, and hornets, when irritated, discharge an acid liquor.

(b) Marine acid differs from the nitrous in another instance, besides those mentioned

in the text. It readily dissolves metallic calxes, which are little affected by nitrous acid. Hence it extracts from most colored earths and stones the metallic calxes, by which the color of these substances is produced.

he calls *mercurial earth*. But he supports his opinion by no other proofs, than by some appearances caused by the union of this acid with metallic substances, in which also he supposes this mercurial earth to be a component part. But as the existence of this mercurial earth in marine acid, or in metallic substances, is not demonstrated, nor even sufficiently indicated; and as Becker has explained himself very obscurely and confusedly on this subject, what he has said does not merit a deliberate discussion. Stahl, therefore, who was too judicious to be satisfied with appearances and probabilities, abandoned, in some measure, this part of Becker's theory, and only expresses a wish that the existence of the mercurial earth could be as well ascertained as the existence of phlogiston.

This great chemist, however, appears to be convinced of the primary identity of all saline substances; that is to say, he believed that they all were the vitriolic acid disguised by some mixture. He assures us, even, that he has been able to transmute acids into each other; that is, to change the vitriolic acid into the nitrous and marine; and to reduce these back again into the vitriolic. But he has not published his experiments on this subject, perhaps because he had not sufficiently ascertained the processes, or that he chose to reserve to himself such important discoveries. The possibility, therefore, of these transmutations of acids is not yet determined. (i)

The properties of the marine acid, above-mentioned, indicate nothing more than that it participates of the nature of both the vitriolic and nitrous acids.

Its combination with phlogiston, which, of all its properties, might assist us most in our investigation, has not been sufficiently explained.

The unsuccessful attempts made by M. Margraaf, a celebrated chemist of the academy of Berlin, to combine the marine acid pure and crude, as he calls it, with phlogiston, with a view to compose phosphorus, are so many fresh causes of uncertainty, and additional motives to endeavor the illustration of this important object. See PHOSPHORUS.

Marine acid, combined to the point of saturation with marine alkali, called also mineral or fossil alkali, forms a neutral salt, crystalizing in cubes, of an agreeable, salt taste. See COMMON SALT under the article SALT.

With volatile alkali it forms a neutral, crystalized, and very pungent salt. This salt is semi-volatile, and may be sublimed with a certain degree of heat. It is called *Sal ammoniac*. See AMMONIAC.

Metallic substances are in general more difficultly dissolved by the marine than by the vitriolic and nitrous acids, because the first has less affinity than the other two with phlogiston, which is the medium of union betwixt metals and acids.

Marine acid, when fluid, however much concentrated, and assisted by any heat, cannot dissolve gold, silver, platinum, or mercury, in their natural or metallic state. It combines however very well and intimately with silver and mercury by two methods. One of these is called the dry method or cementation, because the acid then, in some measure, is dry, and exposed to the greatest heat it is capable of receiving. See PARTING (CONCENTRATED) and SUBLIMATE

(i) Concerning the identity of acids, see the article SALT. Concerning the transmutation of marine acid into the acid of nitre, see also ACID (NITROUS).

(Cor-

(CORROSIVE). The second method is called the *humid way*, and consists in separating these metals from their solutions in nitrous acid. See LUNA CORNEA, and PRECIPITATE (WHITE).

This acid, when pure and unmixed, cannot by any known method dissolve gold or platina. But when it is mixed with the nitrous acid, it forms a menstruum called *aqua regia*, which readily dissolves these metals. See AQUA REGIA. From combinations of *aqua regia* with gold or platina, metallic salts are formed susceptible of crystallization. See GOLD, and PLATINA. (k)

Pure marine acid dissolves sufficiently well tin, lead, copper, iron, zinc, and bismuth; and less easily regulus of antimony: and it forms with these metals different salts, the properties of which see under the articles TIN, LEAD, &c. (l).

The general phenomena, most remarkable in the combination of marine acid with metallic matters, are;

1. It dissolves these substances with less heat and effervescence, and with fewer vapors, than nitrous acid does. This observation is true, even with respect to those metals which it dissolves most readily, as copper and iron.

2. It forms with all the metals which it dissolves, excepting iron and copper, salts capable of crystallization. The cause of this property is, that generally it takes from metals much less of their phlogiston than the nitrous acid does.

3. The metals with which it contracts the strongest union, as silver, lead, mercury, and the regulus of antimony, are actually those with which it unites most difficultly. We must here observe, that marine acid separates silver, lead, and mercury, from the nitrous acid in which they had been previously dissolved; and when it is once united with these metals, they adhere more strongly to it, than they did to the nitrous acid. This has given occasion to Becker and other chemists to advance, that in marine acid, and in the last mentioned metals, there is more of that principle which they call *mercurial earth*, than in any other acids or metals. And to this abundance of mercurial earth, they attribute the stronger connection of marine acid, and the mentioned metals, which are distinguished from all others by the appellations *white*, *lunar*, and *mercurial*.

4. Marine acid has the property of volatilizing, or carrying off with it in sublimation or distillation, entirely or partly, the metals with which it is united, those particularly with which it forms the strongest union, as mercury, regulus of antimony, silver, and lead. See SUBLIMATE (CORROSIVE), LUNA CORNEA, BUTTER of ANTIMONY, and PLUMBUM CORNEUM.

5. Marine acid, though in some respects less strong than the vitriolic or nitrous, forms with metallic substances, and particularly with the last mentioned metals, with which it adheres most firmly, *metallic salts*, much more corrosive than those formed by the other two acids. See CAUSTICITY.

(k) By two methods gold and platina may be rendered soluble in marine acid: 1. by previous solution in *aqua regia*, and precipitation from that menstruum by means of an alkali; or, 2. by a previous calcination with tin or bismuth.

(l) Marine acid, when boiling, dissolves

arsenic. Regulus of cobalt, and the semi-metal called nickel, are also soluble in marine acid: the solution of the former is reddish yellow, which is changed to green by application of heat; and the solution of the latter is of a deep green color.

The greatest part of these phenomena, peculiar to marine acid, evidently proceeds from the difficulty with which it unites with phlogiston, and to the smallness of the quantity of that principle which it takes from metallic substances.

However, these phenomena, thus collected, may, by being compared together, furnish matter for curious speculations concerning the famous mercurial earth of Becker, which, according to him, is the third principle of metallic substances. Besides, in most solutions of metals by marine acid, a singular smell, resembling the smell of garlic, or of arsenic, is exhaled: but, according to Becker, arsenic contains abundantly the mercurial principle.

The difficulty with which marine acid combines with the inflammable principle, is the reason why this acid acts so little upon oils and oily substances. It seems to have no power over these substances when it is fluid and united with a certain quantity of water. What it would produce, if it were artfully applied to these oleaginous matters in its highest degree of concentration, with the help of considerable heat, is not known. Very interesting researches remain yet to be made upon this subject.

It appears that the inflammable principle, when intimately united with water, as in ardent spirits, is in the favorable state for combination with marine acid; although many more difficulties are found in making this combination with the marine acid, than with the vitriolic or nitrous.

Marine acid, mixed with spirit of wine in all proportions, and even frequently distilled with it, is much less intimately combined than the other two acids, and proportionably loses less of its acidity than they do. See SPIRIT OF SALT (DULCIFIED).

Lately, however, marine acid has been applied to spirit of wine in such a manner, that from their union results a liquor which has the distinguishing properties of ether, and is a true *marine ether*. M. Baumé, an able artist, and excellent observer, was the first who published that he had succeeded in making this combination. His method was by applying the vapors of highly concentrated marine acid to the vapors of spirit of wine, by means of a convenient apparatus of vessels. The detail of this fine experiment may be seen in his *Dissertation on Ether*.

Since his time, an illustrious and learned lover of chemistry \* has found a method of making marine ether with infinitely more facility, and more abundantly, by distilling along with spirit of wine the *smoking spirit of Libavius*, which is nothing more than highly concentrated marine acid, charged with a considerable quantity of tin, which it had carried up with it in distillation. See SPIRIT (SMOKING) OF LIBAVIUS.

L. Pott, in his dissertation *de acido salis vinoso*, and other chemists, mention the mixture of some metallic salts, containing concentrated marine acid, such as butter of antimony, with spirit of wine. The phenomena which accompanied these mixtures, shewed that these substances re-acted considerably on each other, and consequently were intimately combined.

\* The Marquis de Courtanvaux.

These phenomena, and particularly the easy production of marine ether, by the smokk, spirit of Libavius, prove that the marine acid which has been combined with metallic substances, is in the fittest state for its intimate combination with spirit of wine, and for the formation of an ether. Does it acquire this property, by depositing along with the metals a portion of some of its principles; for instance, of its mercurial earth; or by carrying off some of the principles of the metals? To me the latter seems certainly the method; and that the metallic principle which it carries off is the phlogiston of the metals. The best means of deciding this interesting question, is to combine the acid with several metallic substances, particularly with those which contain much phlogiston and easily part with it, as zinc, regulus of antimony, tin, and iron, and then to separate the acid from these substances; not only to try whether ether can be made by the acid thus prepared, but also to ascertain by the other means which chemistry affords, whether the acid be really by this method combined with a portion of the phlogiston of the metals. Mr. Pott, as well as Stahl, affirms a fact which confirms these notions, and which well deserves to be ascertained; which is, that the properties of the nitrous acid may be given to the marine by combining the latter with iron. But it is very certain, that the principal difference betwixt these two acids, proceeds from the quantity of phlogiston which enters as a principle into the composition of the nitrous. See ETHER (MARINE).

The affinities of marine acid, according to Mr. Geoffroy's table, are in the following order: tin, regulus of antimony, copper, silver, mercury. According to Mr. Gellert, its affinities are placed thus: phlogiston, zinc, iron, copper, tin, lead, bismuth, regulus of antimony, mercury, arsenic. This table shews also that it does not dissolve gold, and partly dissolves silver by the dry method. (m)

(m) The affinity of tin is greater than that of copper to marine acid, according to Mr. Geoffroy's table, and less, according to Mr. Gellert's table. I have observed that tin readily precipitates copper from this acid, and also from aqua regia: Mr. Gellert is therefore mistaken. The affinities of this, and also of other acids to metals, vary in different circumstances. Thus, for instance, although marine acid unites generally with copper or with iron, preferably to mercury, or regulus of antimony; yet if either of these latter metallic substances be added to a mixture of sea-salt and vitriol, green or blue, and considerable heat applied, the marine acid of the sea-salt, disengaged from its basis by the acid of the vitriol, will not unite with the iron or copper of the vitriol, but with the mercury or regulus of antimony, and along with them will be raised

by the force of the fire, forming mercury sublimate, or butter of antimony.

Mr. Hellot found, that by repeatedly drying and distilling the mother water of sea-salt, more and more marine acid could be obtained without addition.

Marine acid renders calcareous earths and metals soluble in spirit of wine; but not volatile alkali, as nitrous acid does; nor fixed alkali, as acetous acid does.

Marine acid, together with burning phlogiston, gives a reddish yellow flame. The marine acid of mercury corrosive sublimate, combined with copper, forms a fusible mass, which kindles like sulphur, and burns with a blue flame. The phosphorus of Homburg, which is a combination of the marine acid of sal ammoniac with calcareous earth, to which a portion of the inflammable principle of the sal ammoniac adheres, is lumi-

nous

**X. ACIDS (MINERAL).** Mineral acids are those which are obtained from minerals, or substances dug from the earth; such as *sulphur*, *bitumens*, *alum*, *selenites*, *vitriols*, *clays*, all which contain *vitriolic acid*; the *nitrous earths*, from which nitrous acid is obtained; and *Sal-gem*, sea-salt, or *common salt*, which furnish marine acid.

There are then three mineral acids, the vitriolic, nitrous, and marine. These acids are generally more simple, less volatile, more susceptible of concentration, and stronger than the acids obtained from animals or vegetables. Hence their power of decomposing all the neutral salts whose acids are of the latter kind, of disengaging these acids, and of substituting themselves in their place by uniting with the substance, which together with the animal or vegetable acid had formed the neutral salt. See ACID, ACID (VITRIOLIC), ACID (NITROUS), ACID (MARINE).

**XI. ACID (NITROUS).** Nitrous acid has all the general properties of saline acid substances, mentioned under the article Vitriolic Acid. See ACID (VITRIOLIC). But it differs from vitriolic acid in the following circumstances:

1. It is lighter than the vitriolic. The weight of the most concentrated nitrous acid, which can be obtained by ordinary means, is to the weight of water as 19 to 12. See a memoir of Mr. Rouelle concerning the inflammation of oils, in the Memoirs of the Academy for the year 1747.

2. It is of a yellowish-red flame color.

3. It is less fixed than vitriolic acid, and cannot therefore be ever obtained in a concrete form, when unmixed.

4. It perpetually exhales in vapors of the same color as itself.

5. Its smell and taste are peculiar and distinguishing.

6. When highly concentrated, it strongly attracts the moisture of the air, but less strongly than vitriolic acid highly concentrated.

7. When concentrated nitrous acid is mixed with water, a considerable heat and ebullition are produced from the activity with which these two substances combine. While they are mixing, a singular and curious phenomenon appears, which is, that the liquor assumes a blue or deep green color, while the vapors continue still of their original yellowish red. M. Beaumé has made this observation.

This blue color, as the same chemist has remarked, disappears in a few days, if the nitrous acid has been diluted with much water.

Concentrated nitrous acid is very corrosive. It tinges the skin with a yellow color, which does not disappear till the epidermis comes off. It is successfully employed to corrode and gradually destroy warts, and uninfamed, indolent tumors.

nous when struck in the dark. From these facts, together with the preparation of marine ether, we may perceive that marine acid is capable of uniting with phlogiston, and that a marine sulphur might probably be formed, if the volatility of marine acid did not prevent the application of heat sufficient for the forming of that combination.

Homburg found, that marine acid corrodes glass more than any other acid. For the process of obtaining marine acid, see START of SALT.

If



If the opinion of Becker, Stahl, Junker, and all the scholars of Stahl be true, that there is only one primitive acid, whence the rest are formed; and that this most simple acid, the principle of all others, is the vitriolic, then it follows that nitrous acid is nothing else than vitriolic acid, changed by the union of some other principle. Further, these chemists think that nitrous acid is formed from the vitriolic combined, by means of the putrid fermentation, with a certain quantity of phlogiston. To prove their opinion, they give the following reasons:

1. That the nitrous acid is obtained from nothing else than materials impregnated with putrid juices of animal and vegetable substances, which are known to abound with phlogiston: whereas vitriolic acid exists, not only in most minerals, and in the very earths and stones, which are fittest to form a matrix for the generation of nitrous acid, but also in the atmosphere, as appears from the experiment of exposing to the air linnen soaked in a lixivium of alkaline salt, which in a certain time is found to be changed into vitriolated tartar.

2. There is a great analogy betwixt those properties of the nitrous and volatile vitriolic acids, by which each of these acids differs from vitriolic acid, and volatile vitriolic acid is evidently vitriolic acid changed by union with phlogiston.

This volatile vitriolic acid differs from vitriolic acid by its volatility, by its smell, by its weaker adhesion to alkaline salts, by the greater solubility and different form of the crystals resulting from its union with alkaline salts.

But these properties are the same which distinguish nitrous acid from the vitriolic. Besides, the volatile vitriolic and nitrous acids resemble each other, and differ from vitriolic acid in the following respects: 1. They produce a much greater alteration on the colors of vegetables than the vitriolic does: and 2. The salts formed by their combination with fixed alkali resemble each other, and are equally different from vitriolated tartar.

Several new interesting experiments might be made to determine more particularly the analogy betwixt the volatile vitriolic and nitrous acids. The salt resulting from the combination of volatile vitriolic acid and absorbent earths might be examined, in order to discover whether it be deliquescent, like the salt from the combination of the same earth with nitrous acid, and in what other circumstances these two salts resemble each other, and differ from the vitriolic salt with earthy base, or selenites. This inquiry would be still more interesting, as the nitrous salts with earthy bases have also been little examined. See SALTS (NITROUS) with EARTHY BASES.

Nitrous acid is one of the most powerful menstruums in chemistry: not that it is the strongest acid; for in strength it is inferior to vitriolic acid, and even in certain circumstances to marine acid: but on account of the facility, of the quickness, and of the activity with which it dissolves many substances.

The bodies upon which it acts most forcibly are, phlogiston, alkalies fixed and volatile, metallic substances and earths, particularly of the calcareous and absorbent kinds.

Nothing can equal the impetuosity with which nitrous acid joins itself to phlogiston. It is so great, that probably nitrous acid has a stronger affinity with phlogiston than the vitriolic has: and it is probable too, that

tin, which the nitrous acid deprives of its phlogiston, and in some sort calcines rather than dissolves. See TIN. (o).

XII. ACID (PHOSPHORIC). See PHOSPHORUS.

XIII. ACID (VOLATILE SULPHUREOUS, or VOLATILE VITRIOLIC). This is nothing else than vitriolic acid diluted with water, and weakly united to the inflammable principle. The properties of this acid are then the same *essentially* as those of vitriolic acid. See ACID (VITRIOLIC). But the phlogiston which is united with the volatile acid makes it differ considerably from the pure vitriolic acid.

It differs from vitriolic acid, 1. By its smell, which is so active and penetrating, that it can instantaneously suffocate and kill animals. This smell is the same as that of lighted sulphur. As vitriolic acid, when pure and free from phlogiston, has no smell, it appears that the smell of volatile vitriolic acid is caused by its phlogiston; and this is one of the best proofs of the opinion of Stahl and other chemists, who think that phlogiston is the principle of all odors. This opinion will appear even demonstrated, when we consider that no odoriferous substance can be found, in which it is not easy to shew the presence of phlogiston. See PHLOGISTON.

2. The volatile acid differs from the vitriolic by its volatility. The latter is the most fixed of the mineral acids, and is for that reason the most susceptible of concentration: but the volatility of the former is so great, that it cannot be much concentrated. This property proves that phlogiston is a principle essentially volatile.

3. The volatile acid is infinitely weaker than vitriolic acid; not only because it cannot be so much concentrated, but also because by its combination with phlogiston it is rendered less simple, and consequently less capable of affinity with other bodies. Therefore, the neutral salts formed by it with alkalies, are easily decomposed by vitriolic acid, and also by all other acids, even the weakest amongst the vegetable.

4. The neutral salt which results from the union of volatile vitriolic acid and fixed alkali, differs much from vitriolated tartar with respect to the figure of its crystals, which are long and needle-like, arranging themselves together in form of tufts or shrubs. Its taste also is different from that of vitriolated tartar, and it is more soluble in water: all these properties shew in a

(.) Nitrous acid forms with copper, a green; with iron, a reddish; with lead, a yellow; and with silver, bismuth, mercury, &c. zinc, colorless solutions. Tin it dissolves imperfectly, and it corrodes regulus of antimony to a white powder. With regulus of cobalt it forms a red, and with ruckel a green solution. It dissolves arsenic, and, according to Henckel and Neumann, forms with it a gum-like substance. Dr. Brandt found that by particular management it can dissolve gold: See GOLD. It has little effect on metallic calxes.

Nitrous acid combined with chalk forms the phosphorus of Baldwin. See PHOSPHORIC STONES. Cohobated and distilled with quicklime, it emitted an inflammable vapor. See Mr. Pott's *Dissertation on the Solution of Quicklime by Nitrous Acid*. With ice this acid produces cold remarkably. Concerning the origin of nitrous acid, see NITRE and SALT; and for the process of obtaining it, see SPIRIT of NITRE.

neutral

neutral salt the weak union of its acid and base. This salt is called the *sulphureous salt of STAHL*. See SALT (SULPHUREOUS).

5. The action of volatile vitriolic acid is much more evident than of vitriolic acid upon the colors of vegetables, as appears by pouring an equal quantity of each of the two acids into the tincture of violets, or of heliotrope, of cochennille, Brasil wood, &c. In all these instances, the tinctures into which volatile vitriolic acid has been poured, will have lost much more of the intensity of their colors than the other tinctures; that is to say, their colors will be more changed, enlivened, and heightened. This effect is produced to such a degree by this acid, that it destroys most colors, and makes them disappear entirely in time. This property renders it very useful in several arts, by giving to certain matters, for instance to wools and silks, a degree of whiteness to which they could not be otherwise brought. For this purpose, these matters are exposed in a close place to the fumes of burning sulphur, from which, as we shall afterwards see, much of this acid exhales. See SULPHUR.

Although volatile vitriolic acid differs essentially from nitrous acid, since the former is nothing else than vitriolic acid disguised by the addition of phlogiston, which is but weakly united to it; nevertheless, it is necessary to remark, that all the properties now recited of the volatile acid, make it resemble nitrous acid as much as they distinguish it from vitriolic acid. From this remark may be drawn one of the strongest presumptions in favor of Stahl's opinion concerning the nature of nitrous acid. This great chemist thinks, that vitriolic acid, which he therefore calls the *universal acid*, is the principle of all other acids, and the most simple of all. He thinks that nitrous acid is particularly nothing else than vitriolic acid combined by means of putrefaction with a certain quantity of phlogiston; but in a manner very different, and infinitely more intimately than the phlogiston is combined in volatile vitriolic acid. For this latter combination is so weak, that it is decomposed by contact of air; so that the most strong and penetrating volatile vitriolic acid, by exposure in open vessels, loses in a little time all its smell and volatility, and becomes entirely similar to a pure and weak vitriolic acid. The same phenomenon takes place when the volatile acid is combined with an alkali. Hence the sulphureous salt of Stahl, exposed for a while to free air, loses all the properties which distinguish it from vitriolated tartar, and becomes no wise different from it.

The true reason of the weakness of adhesion of the phlogiston in volatile vitriolic acid, is the presence of the aqueous principle, above the quantity of water essential to vitriolic acid. This principle always resists a strong and intimate union of phlogiston with any body.

This is so true, that if vitriolic acid deprived of all water except what is essential to it, be applied to any matter containing phlogiston, volatile vitriolic acid is not then produced, but true sulphur, in which the phlogiston adheres more strongly. See SULPHUR. On the contrary, when a vitriolic acid, overcharged with superfluous water, is combined with a matter containing phlogiston, volatile vitriolic acid is constantly produced, and never sulphur, except that in the very act of combination the vitriolic acid be deprived of all its super-abundant water.

The great facility which vitriolic acid has to combine with phlogiston, even when superfluous water is mixed with it, furnishes many methods of producing abundantly this volatile vitriolic acid.

Stahl proposes two. The first is, by burning sulphur as slowly and gently as possible. The acid which exhales in this operation is very volatile, very phlogisticated, and very suffocating; for two reasons: 1. Because of the little activity with which the sulphur burns, the inflammable principle is not entirely consumed, but a portion of it remains united to the acid: and, 2. Because when the vitriolic acid, which in sulphur is in its highest degree of concentration, and even in a state of perfect dryness, disengages itself by degrees, during the slow burning of the sulphur; it finds in the air a portion of water which it greedily seizes, and which renders it fit to be changed with the remaining phlogiston into volatile vitriolic acid. When sulphur is burnt hastily and strongly, little or no volatile vitriolic acid is produced, principally because then almost all the inflammable principle of the sulphur is destroyed by this perfect inflammation.

This first method of obtaining the volatile vitriolic acid is the best and easiest, when it is not intended to collect it, but to apply it to some body as soon as it is produced; as, for example, to kill insects or noxious animals, to whiten wools and silks, to sulphurate wines, or to produce the sulphureous salt of Stahl. See SALT (SULPHUREOUS. See also SULPHUR). But this method is improper for collecting the volatile acid, because sulphur cannot burn in close vessels.

The second method proposed by Stahl for obtaining the volatile vitriolic acid, is by distilling green or martial vitriol in a cracked retort, to which a receiver is properly luted. By this method a considerable quantity is produced and collected; because, 1. The phlegm of the martial vitriol supplies the necessary water to the vitriolic acid; and, 2. Enough of the phlogiston of the burning coals passes through the crack of the vessel, to form volatile vitriolic acid. This method, though very good in itself, is subject to a very great inconvenience in practice; which is, that when cracked retorts are exposed to the fire with the greatest caution, they are very apt to break still more, and entirely to fall in pieces, by which the operation is spoiled.

This inconvenience may be avoided by distilling in a good retort, not cracked, a mixture of vitriolic acid, or substance containing it, and any matter capable of furnishing at once water and phlogiston. Thus spirit of wine, oils, fat, resins, &c. mixed and distilled with vitriolic acid, can always furnish a good quantity of strong volatile vitriolic acid. See OIL and ETHER (VITRIOLIC).

This acid ought to be kept in crystal glass bottles, closed exactly with glass stoppers; and to be as little as possible exposed to air, because vapors always escape from it when so exposed, by which its strength is impaired from the dissipation of part of its phlogiston.

This great facility which the phlogiston has to separate itself from volatile vitriolic acid, is the cause of the exceeding difficulty, and even impossibility of determining precisely the quantity of phlogiston necessary to convert any given quantity of vitriolic acid into volatile vitriolic acid. In general, we know that very little is required; a single drop of oil being capable of converting, by distillation, a large quantity of vitriolic acid into very strong volatile acid.

It is no less difficult to determine certainly and precisely the properties of this acid as a menstruum of different substances; as, for example, earths and metals. This difficulty also proceeds from the facility with which it parts with its phlogiston, and consequently changes its nature, which it does more or less in the act of combination with the substances it dissolves. It is an acid perpetually changing, and which we cannot be certain of having the same at different times.

These difficulties ought not to prevent trials of such combinations, hitherto little known. Because in an important and essential enquiry, which may throw new light upon the theory of acids and phlogiston, even approximations become important and essential.

**XIV. ACID (TARTAREOUS).** See TARTAR, and CREAM of TARTAR.

**XV. ACIDS (VEGETABLE).** All acids obtained from vegetable matters are so called. Such are the juices of sour fruits, wine turned sour, or vinegar; crystals of tartar; all the essential acid, concrete salts, procured by crystallisation from the expressed juices of plants; and lastly, all the acids obtained from vegetable substances in analysing them by distillation.

These acids differ from mineral acids in being less simple, less fixed, less susceptible of concentration and weaker; qualities, which proceed from their union to a certain quantity of oil, with which they are so intimately combined, that they cannot be separated from it but by very nice and studied operations. Hence all the neutral salts formed by these acids may be decomposed, either by the mere action of the fire, or by any mineral acid whatever.

The particulars of what is here advanced in general on their properties and principles, may be seen under the articles of the principal vegetable acids.

**XVI. ACID (VITRIOLIC)** was so named, because, formerly, it was chiefly obtained from martial vitriol. It is, according to the very probable opinion of Becker and of Stahl, the simplest of all acids, and consequently the simplest of all saline substances. When it is as pure as can be obtained, it is entirely free from smell and color; that is to say, in these respects, it resembles water.

It possesses most eminently all the properties characterising saline, and particularly acid substances.

It tastes exceedingly sour, and it sets the teeth on edge.

It changes to red the color of syrup of violets, of tincture of heliotropium, &c.

It is very susceptible of concentration; that is, much of the water unnecessary to its saline essence may be raised by distillation. See CONCENTRATION.

The specific gravity of this acid, when much concentrated, is very great. It is more than double the specific gravity of water, sometimes as 17 to 8, and perhaps might be further concentrated. M. Hellot, in pushing strongly the distillation of martial vitriol, continued towards the end of the operation a vitriolic acid so concentrated, that it was solid and crystalline. Some chemists have given to vitriolic acid so concentrated as to become concrete, the name of GLACIA, or Ice Oil of VITRIOL.

Vitriolic acid highly concentrated, is less fluid than water. It pours rosey like oil, and feels to the fingers greasy. These two last properties have occa-

found the ancient chemists to call it *Oil of Vitriol*. This name is very improper, since it is not inflammable, nor has any peculiar properties of oils. See OILS. Its only consistence is owing to the great approximation of its parts, and its apparent unctuousity proceeds from the same cause; joined to this, that as it is a very powerful dissolvent, it attacks and dissolves effectually a portion of the unctuous substance of the skin which it touches.

The very strong and concentrated vitriolic acid is not only much heavier, but also much more fixed than water. Hence it is capable of receiving, when exposed to fire, a degree of heat greatly superior to that of boiling water, and which almost amounts to a red heat.

This acid when well concentrated, (which we suppose here all along) unites itself to water with an astonishing activity and impetuosity. If two or three ounces of it be mixed with as much pure and cold water, the re-action of these two substances on each other is so strong, that instantly a boiling arises, attended with many vapours, and a noise similar to that of a red-hot iron plunged into water. The heat resulting from the re-action of these two cold liquors is so great, that in an instant it equals, and even much surpasses the heat of boiling water. Some chemists have attributed this heat to a disengagement of the igneous particles contained in vitriolic acid. This is not true, except they only mean the igneous particles contained in this acid, as in all other substances, and which are set in motion by all collisions; but not any superabundant igneous particles peculiar to this acid, since no experiment demonstrates their existence.

The concentrated vitriolic acid, exposed to the atmosphere, attracts moisture so much, that its bulk is considerably increased, and it becomes mixed with twice its weight of water. (p)

It may be combined with the inflammable principle or phlogiston, and thereby form two compounds, differing from each other in the quantity of phlogiston, and in the closeness of the union.

The first, which is the result of a combination of weak vitriolic acid with a small quantity of phlogiston, is called volatile, sulphureous, or vitriolic acid. See ACID (SULPHUREOUS); and the second, which arises from an intimate union of vitriolic acid, freed from all water above what is necessary to its essence as a saline substance, with about a seventh part of its weight of pure phlogiston, is called *Sulphur*. See SULPHUR.

Earths are more or less soluble by vitriolic acid, according to their natures; and form with it different salts, or earthy saline compounds of different properties, according to the kinds of earths employed. Particular management is requisite to combine vitrifiable earths with vitriolic acid: and the salts resulting

(p) Dr. Gould relates, that three drams of concentrated vitriolic acid acquired by imbibing moisture from the air, in 57 days, an increase of six drams and a half; and that in general this acid acquires increase of weight in a compound ratio of the largeness of the surface exposed, and of the humidity of the atmosphere. Newman

found that an ounce of this acid, by exposure to air during a year, had imbibed more moisture than six times its original weight. For the method of obtaining this acid, see SPIRIT of SULPHUR, CLYSTER of SULPHUR, and CONCENTRATION of VITRIOLIC ACID.

from

from their combination have not yet been sufficiently examined. See VITRIFIABLE EARTHS and LIQUOR OF FLINTS.

Calcareous earths may be dissolved without any previous preparation by vitriolic acid. This solution is made with moderate effervescence; and from this combination results an earthy saline compound, susceptible of crystallization, whose principles are so intimately combined, that the saline properties of the vitriolic acid are almost entirely masked by those of the earth which is the prevailing principle (see AFFINITY); so that this neutral vitriolic salt with earthy basis has no sensible taste, and is scarcely soluble in water: according to Mr. Baumé's experiment, one grain only of it could be dissolved in an ounce of water. This want of saline properties, which appears common to all vitriolic salts with bases of calcareous earth, has occasioned them to be distinguished by the name of *Selenites*, from other combinations whose saline properties are more obvious. See SELENITES.

Alum is a vitriolic salt with earthy basis, but it differs considerably from Selenites. This difference proceeds from the nature of its earthy basis, which is not calcareous, but argillaceous. See ALUM.

Vitriolic acid may be combined and saturated with vegetable fixed alkali: and from this combination is formed a neutral salt, capable of being crystallized, bitter, hard, and not easily soluble in water. Several names have been given to this salt from the several substances whence its alkaline basis was extracted, at a time when these alkalis were supposed to differ from each other. These names are, *Sal de duobus*; *vitriolated tartar*; *arcantum duplicatum*. See these words, and ALKALI (VEGETABLE.)

With the alkaline basis of sea salt, called marine or fossil alkali, the vitriolic acid forms a neutral, crystallizable salt, called *Glauber's salt*, which differs from vitriolated tartar in the figure of its crystals, its greater solubility in water, the quantity of water contained in its crystals, and its property of drying in the air, or losing much of its water, by which the crystals lose their transparency, their solidity, and are reduced into a white meal, called *efflorescence*. See ALKALI (MARINE), and SALT of GLAUBER.

Volatile alkali combined to the point of saturation with a vitriolic acid, forms a neutral ammoniacal salt, and crystallizable, called *Salt (vitriolic ammoniac)*, which see, and ALKALI (VOLATILE).

Vitriolic acid being more simple and more powerful than the nitrous and marine acids, separates them from the alkalis to which they are united, and substitutes itself in their place. See NITRE and SALT (COMMON).

In general, this acid acts upon all metallic substances, and dissolves them with phenomena peculiar to each. It forms with them neutral salts with metallic bases capable of crystallizing; to all which salts M. Macquer thinks proper in his course of chemistry to give the general name of *vitriol*, and to specify the different vitriols by the name of the metallic matters which enter into their composition. Thus, for example, he proposes to call the combination of vitriolic acid with silver, *vitriol of silver*, or *lunar vitriol*; and the combination of the same acid with mercury, *vitriol of mercury*, &c. in the same manner as the neutral metallic salts formed by the union of vitriolic acid with iron and with copper, are called *vitriol of copper*, and *vitriol of iron*, or *martial vitriol*. See VITRIOL.

This acid, in consequence of its great affinity with the inflammable principle, attacks the phlogiston of metals when it dissolves them, and separates part of it from those which are capable of being deprived of it; consequently it calcines them more or less according to their nature, and to the manner of making the solution, and adheres to them proportionably less, as it has taken from them a greater quantity of their phlogiston. We may conclude from these phenomena, that vitriolic acid dissolves metals chiefly by means of their phlogiston; or that this principle is a medium of union between this acid and metallic earths.

The most general phenomena accompanying the solutions of metallic matters in vitriolic acid by the humid method, are, 1. The effervescence and heat, which are commonly moderate. 2. The vapors; many of which are the volatile vitriolic acid, as in the solution of mercury; or they are inflammable vapors, as in the solution of iron. 3. The formation of concrete sulphur, as in the solution of tin. See the particular details of all these solutions of metallic matters by vitriolic acid, under the article of each metallic substance, and at the word VITRIOL. (q)

It appears from what has been said on the combinations of vitriolic acid with all the substances with which it can form a neutral salt, that all these neutral vitriolic salts are susceptible of crystallization. This property is peculiar to vitriolic acid, and probably proceeds from the intimacy of union contracted betwixt this acid and the substances which it dissolves.

Concentrated vitriolic acid acts with considerable force on all oils and concrete oily matters. It boils and grows warm when added to them. It partly

(q) Diluted vitriolic acid dissolves iron and zinc speedily, and copper very slowly. Boiling concentrated vitriolic acid dissolves copper, and partly dissolves and partly corrodes silver, tin, mercury, and lead. Vitriolic acid does not directly dissolve gold, but precipitates it from aqua regia, which precipitate is soluble in vitriolic acid. It lessens the volatility of mercury and of arsenic; and the fusibility of lead, zinc, bismuth, and regulus of antimony. It dissolves the calxes of most metals. It also dissolves the semi-metal, regulus of cobalt, but not nickel.

Although vitriolic acid has a strong power to combine with iron, yet its adhesion to it when dissolved seems to be very weak. Thus Mr. Margraaf found, that by boiling a solution of green vitriol in a copper vessel, or with filings of copper, part of the iron was deposited, and in its place part of the copper was dissolved. This experiment is so much more remarkable, as a diluted vitriolic acid has no sensible effect upon copper in a short time. The acid therefore by its previous solution of iron seems to have been so changed, as to be rendered capable of dissolving copper. This experiment does not contradict

the general rule by which the power of union of vitriolic acid is affirmed to be greater to iron than to copper, but may be explained from the slight adhesion of the inflammable principle to the earth of iron; by which property salts formed by this metal with vitriolic or nitrous acids are continually decomposing; the phlogiston, which is the medium of union betwixt acids and earths, escaping into the air or combining with the acid, and the calx of iron separating from the acid, in form of a red sediment. This decomposition of martial vitriol, and martial nitre, and also of some other metallic salts subject to the same change, is accelerated by application of heat, air, moisture, and, as Mr. Margraaf's experiment seems to indicate, by the application of another metal, as copper. Mr. Margraaf has not given his sentiments concerning the cause of the alteration produced upon the acid in his experiment, by which it is rendered capable of dissolving copper. Is it by absorption of the phlogiston of the iron, that it becomes volatile vitriolic acid, and thereby acquires new properties as a menstruum?

decomposed



decomposes them, blackens, and in some sort burns them. From these mixtures many fumes exhale, which have a mixt smell of burnt oil, and very suffocating volatile vitriolic acid. See the detail and explanation of these phenomena at the word **OIL**.

Vitriolic acid, when very weak, does not appear to have any action upon oils, because its superfluous water, with which it strongly adheres, hinders it from combining with these substances, to which the water cannot be united. However, the union of such a weak vitriolic acid with oil, does not seem impossible. See **OIL**.

Concentrated vitriolic acid shews, when mixed with spirit of wine, many very interesting phenomena, and which vary according to the proportions of these two acids, and the management employed.

Without distillation, it entirely combines in substance with spirit of wine, without occasioning any decomposition; that is to say, it does not combine with any of the principles of the spirit of wine preferably to the rest. It loses its acidity by this union, and is rendered greatly milder. Hence it is called *Dulcified Vitriolic Acid*. It has also been called **WATER of RABEL**; which see.

When spirit of wine and vitriolic acid are distilled together, the latter decomposes the former, takes possession of its aqueous principle, reduces a part of it into a middle substance betwixt ardent spirits and oil, to which the name *Ether* has been given; and lastly, the acid reduces the spirit of wine into a true oil, which has been improperly called *Sweet Oil of Vitriol*. See the words **SPIRIT (ARDENT)**; **ETHER**; **ETHER (VITRIOLIC)**; and **SWEET OIL of VITRIOL**.

Vitriolic acid is no where in nature found pure; that is, unmixed with any other matter. This proceeds from its capacity to dissolve, and to combine with a great variety of different substances.

Thus vitriolic acid is found naturally combined, 1. With an inflammable substance; then it is in form of sulphur or bitumen; or, 2. With earthy substances in form of selenites, aluminous and argillaceous matters; or, 3. With metallic substances, in form of natural vitriols; or, 4. With alkaline salts, in form of neutral vitriolic salts with alkaline bases. But it is almost only with the fossile or marine alkali that the vitriolic acid is ever found naturally combined, because this alkali is most generally diffused, and is indeed almost the only natural alkali. Vitriolic acid is therefore found in form of Glauber's salt. Natural Glauber's salt is chiefly found in those waters which contain common salt. See **SALT (COMMON)** and **WATERS of SALT FOUNTAINS**.

Vitriolic acid, combined with vegetable fixed alkali, forming vitriolated tartar; or with volatile alkali, forming vitriolic ammoniac salt, otherwise called the secret ammoniac salt of Glauber; can be found but very rarely, and by particular decompositions and combinations; as, for example, by burnings.

From what has been said concerning the states in which vitriolic acid is naturally and habitually found, we may perceive that it cannot be obtained alone and pure without particular artful operations; that is, by decomposing those bodies which contain most of it, and from which it may be easiest procured. These bodies are *Sulphur* and *Vitriols*. See these words for the extraction of *Vitriolic Acid*.

Upon considering the several substances with which vitriolic acid is found naturally combined, an interesting question arises concerning the original and primitive state of this acid. For as sulphur is spread in very large quantities within the earth, and that by its burning or decomposition, its acid separated from its phlogiston becomes capable of combination with earthy and metallic substances, as happens actually in the fabrication of vitriols and of alum; we may consider whether all vitriolic acid has been originally in the state of sulphur; and if one part of this sulphur being consumed or decomposed by natural causes, as happens in volcanos, its acid has formed all the vitriols and vitriolic salts with earthy bases, which are found formed in the earth; or whether, as we know by the experiment of the artificial composition of sulphur, that vitriolic acid quits every other substance in order to combine with phlogiston; all this acid was originally combined with earthy and metallic substances; and these vitriolic salts, meeting matters abounding in phlogiston, have been decomposed to form all the sulphur found in the earth. This question cannot certainly be decided but by the profoundest researches into the natural history of these several bodies.

The affinities of vitriolic acid according to Mr. Geoffroy's table are, phlogiston, fixed alkali, volatile alkali, earths, iron, copper, and silver: and according to Mr. Gellert's table, phlogiston, fixed alkali, volatile alkali, earths, zinc, iron, copper, silver, tin, lead, mercury, bismuth, regulus of antimony, and arsenic.

**XVII. ACIDS (VOLATILE).** These acids are so called which are more volatile than most other acids; which volatility proceeds either from an union of some phlogiston, or of some attenuated oil. Such are the volatile vitriolic acid; the acid spirits of some acrid vegetables, as the roots of squills, according to Mr. Cartheuser; the acids which rise when butter or fat are distilled; and others similar.

**XVIII. A D E P T** is the name assumed by those alchemists who pretended to have discovered the philosopher's stone. See **STONE (PHILOSOPHER'S)**.

**XIX. A D O P T E R.** See **RECEIVER**.

**XX. A F F I N I T Y.** By affinity (*r*) is understood that tendency which the constituent or integrant parts of bodies have to unite, and that power by which they adhere when united.

The definition of affinity shews that it is not a word void of meaning. The power with which the parts of bodies tend to unite with each other, and their adhesion when united, are very sensible and palpable effects, since this power cannot be destroyed but by another power as real and more considerable. It is

(-) By the terms *affinity*, and *electro attraction*, we ought to understand the power by which the constituent parts of bodies unite, and not to suppose that this power is exerted by any similarity and homogeneity of parts, or by any mechanical traction, as these terms seem to imply. The cause of this power, or the manner in which this union of constituent parts, is produced, is unknown to us. To these terms, therefore, another less exceptionable, namely, *the power of combination*, may be substituted. In our author's definition of affinity is comprehended not only the power of union of the constituent parts of bodies, which is the proper object of chemistry, but also the power of union of the integrant parts of bodies, which he calls the affinity of aggregation, and which is treated of by writers on natural philosophy and mechanics under the term attraction.

besides demonstrated by numberless experiments ; as, for example, by the adhesion of two bodies applied to each other, whose surfaces are finely polished ; by the tendency which two drops of water, or of oil, mercury, or of any other fluid, have to run together and unite into one mass ; by the convex or spherical figure which drops of fluids assume, when their form is not given them by containing vessels or other body, and when they are supported by bodies with which they are not disposed to unite : all which effects happen even in a vacuum, and demonstrate the affinity which the integrant parts of bodies solid, or fluid, have to each other.

The affinity of the constituent parts or principles is demonstrated by the detail of all the phenomena in chemistry.

We do not here enquire into the cause of this great effect, which is so general, that it may itself be considered as the cause of all combinations, and may serve to explain them. It may perhaps be a property as essential to matter as its extent and impenetrability, of which we can say no more, than that such properties do exist. On this subject the works of Newton, Freind, Keil, and the Abbé Marcuzzi, may be consulted. These authors have endeavored to illustrate these obscure subjects by calculation. We shall be satisfied with observing the most remarkable laws, according to which the principles of bodies unite and combine, in consequence of this property.

M. Macquer distinguishes several sorts of affinities. Not that he believes there are distinct species of affinities ; for it is very certain, that it is but one and the same property of matter, differently modified according to different circumstances ; but only that he may better distinguish and remark the phenomena occasioned by this property, in the detail of the combinations and separations which it effects in the most general and most important operations of chemistry.

By *simple affinity* he means the disposition to unite and adhere, which is observed between the integrant and homogeneous parts of the same body, or between the heterogeneous parts of two different bodies. The simple affinity is therefore distinguished into two kinds.

The first kind of simple affinity produces the *union of aggregation* ; that is to say, that the body resulting from this union is of the same nature, but of larger size. M. Macquer calls it the *affinity of aggregation* ; as, for example, when several loose particles of the same metal or of the same earth are united together by fusion, so as to form but one mass. See AGGREGATION.

The second kind of simple affinity, producing the union and adherence of heterogeneous parts, different in their natures, from which results a new compound body, whose properties are different from those of the two principles

attraction, gravitation, and cohesion. Whether these two unions are produced from the same cause differently modified, as our author affirms, I know not ; but their effects are so different, that they deserve to be considered separately : the union of integrant parts being only an apposition of these parts, which are capable of being disjoined by

mechanical means, and without any change produced upon their properties ; and the union of constituent parts, or combination, being attended with considerable changes of properties, and being incapable of disjunction by mechanical means. See the article COMPOSITION of Bodies, and the following Note.

from

from which it was formed, is called *affinity of composition*; because a new body is actually composed. If, for example, the primitive integrant parts of vitriolic acid be united with those of iron, a new body results from this union, which is neither vitriolic acid nor iron, but a compound of the two, called *martial vitriol*.

The following remarks may be made on simple affinities.

1. That the affinity of aggregation resists the affinity of composition. For it is evident that the force which makes the homogeneous and integrant parts of a body adhere together, hinders them from separating, in order to join the parts of another body.

2. Hence it follows, that if the adhesion of aggregation between the integrant parts of a body be weakened or destroyed, the affinity of composition is thereby facilitated; that is, the affinity which they have to join the parts of another body.

3. That as the hardness of a body supposed simple and homogeneous depends only on the adhesion of aggregation betwixt its integrant parts, if this adhesion be destroyed by separating these parts from each other; as by reducing them into fine powder, or still more by diffusing them in a liquid, with which they have no adhesion, or less than they had to each other; they may then be combined with the parts of another body, more or less easily, in proportion as they have been more or less separated by this mechanical division.

4. As different bodies are more or less susceptible of this mechanical division, whether artificial or natural, by which their integrant parts are more or less separated from each other, hence arises a great difference betwixt these bodies in their greater or less facility of combining with other bodies.

5. This facility of combining with another body does not, however, determine solely the degree of affinity betwixt these two bodies. For experience shews that principles or constituent parts of certain compounds, which unite together very readily and easily, have however but a weak adhesion, which is destroyed by the smallest effort of analysis, or chemical decomposition; while other principles which can be united only with great difficulty, and by studied means, contract together an union much stronger, and much less apt to be dissolved. Mercury, for instance, unites much more easily with nitrous acid than with the marine, but yet it adheres much more strongly to the latter than to the former.

Hence we ought to conclude, that we cannot positively determine that one body has no affinity with another body, because no means are known of uniting them. On the contrary, it appears certain that all natural bodies have a certain degree of affinity, and facility of uniting with each other, and a certain degree of adhesion when they are united, and consequently, that there are no combinations really and absolutely impossible; but that this degree of affinity varies according to the different states in which these bodies are found.

However, as the want of union betwixt two bodies prevents their affinity from shewing itself, we may consider bodies which we cannot combine as having no affinity together, until chemistry be so far advanced as to make combinations which now seem impossible. Thus, for instance, oil is said to have no affinity with water, nor lead with iron, nor iron with mercury; because, in fact, these bodies cannot be directly united together in chemical operations. Thus any affinity which they may have together is to us of no consequence.

On the contrary, as the affinities of bodies which may be united together, produce in chemical operations effects proportionable to their facility of union, and to their force of adhesion when united, we may consider the affinity of bodies in general, as being in a compound ratio of these two properties.

The last remark we can make on the simple affinity of composition, furnishes a very useful and very general fundamental law, by which we may discover, even without decomposition, the principles of which bodies are composed. The remark is, that all compound bodies have properties partaking of the properties of the principles of which these bodies are composed. Thus, for example, the union of two principles, of which one is fixed, and the other is volatile, forms a compound, whose degree of fixity or volatility is intermediate betwixt those of the two principles.

The same may be said of all the other properties; such as gravity, opacity, transparency, ductility, hardness, fluidity, &c. and even of the affinities: so that, supposing we knew perfectly the properties of the principles of a compound, we might by examining the properties of this compound, discover its principles, even although its analysis were impossible.

We must however allow that this rule, although very general, is subject to a considerable number of restrictions and modifications, which depend on a number of particular circumstances. For example: it happens sometimes that the operation by which two principles are united changes or even annuls some of the properties of these principles: it happens too that sometimes their union develops new properties, which cannot be immediately perceived in either of the principles. But such changes are never so compleat as to lead one into gross mistakes concerning the principles; therefore they do not prevent the rule from being sufficiently general, to be an excellent guide in many chemical enquiries. (s)

Where more than two bodies act upon one another, the *affinity* may be called *complicated*; and from the definition given, it appears that all these complicated affinities must be of the kind called *Affinity of Composition*.

(s) The rule mentioned in the text is so far from being general, that perhaps the reverse of it may be considered as a general rule; and a change of properties, and a production of new properties, may be considered as criterions, by which compound bodies, chemically combined, may be distinguished from bodies formed merely by mixture or apposition of integrant parts; in which latter compound bodies, the properties are intermediate betwixt the properties of the several component parts, and no new properties are produced. Thus, three parts of copper combined by fusion with one part of tin, forms a body more hard, more brittle, and more sonorous, than either of the constituent metals. Its hardness, therefore, its brittleness, and its sonorousness may be considered as new properties. Its color

is much whiter than the intermediate color, and its specific gravity is greater than the intermediate specific gravity. Further, the properties of bodies are in many instances destroyed or annulled by chemical combination. Thus the acrimony and deliquescentcy of acids and of alkalies are almost entirely annulled by combining these two kinds of substances together. Every body chemically combined may furnish facts which refute the general proposition mentioned in the text. Bodies formed by mixing, not by chemically combining several substances together; as, for instance, a liquor formed by mixing wine and water; partake of the qualities of each ingredient, proportionably to the quantity of it employed. See COMPOSITION of BODIES, and AGGREGATION.

First, we ought to consider that complicated affinity in which only three principles act. Experience indicates the following observations.

If a principle be added to two other principles united together, phenomena of composition or of decomposition happen, which differ according to the affinities of these three bodies to each other.

1. Sometimes the third supervening principle is united to the other two, and forms together with them a compound consisting of three principles. For example, if to a mass composed of gold and silver, some copper be added, this third metal is united to the other two, and forms with them a compound consisting of three principles, namely, gold, silver, and copper. Thus it happens, when the third supervening principle has with the two others an affinity equal, or almost equal to the affinity which these two principles have to each other.

2. The same thing also happens sometimes, although the third supervening principle has no affinity with one of the two principles originally united. But then it is necessary that this supervening principle should have, with the other of the two principles, an affinity equal to the affinity subsisting between those two principles originally united. And in this case, that principle which serves to connect and unite the two which could not otherwise be united, is called an *intermedium*. This affinity may also be called the *affinity of intermediums*. For example, if water be added to the compound called *liver of sulphur*, which consists of two principles, sulphur and fixed alkali, it unites with the water, dissolves in it without being decomposed, and forms a new compound consisting of three principles, namely, sulphur, fixed alkali, and water. The water and sulphur could not by themselves form any union: but as fixed alkali has a great affinity with both sulphur and water, it serves upon this occasion as an intermedium to unite these two substances together. It is necessary to remark, that in this affinity of intermediums, the affinity of the principle which serves as an intermedium is weakened, because it is divided betwixt two bodies; and that the union contracted with them is less strong than if it were united to one of them only.

3. Sometimes a third principle, when added to a compound consisting of two principles, does not unite but with one of these two principles, and obliges the other to separate itself entirely from the principle with which it was originally united. In this case a total decomposition happens of the first compound, and a new combination of the remaining principle with the supervening principle; from which a new compound results. This happens when the supervening principle has little or no affinity with one of the principles of the compound; and when it has with the other, an affinity much stronger than that which subsists betwixt the two first principles. For example, when an alkali is added to a solution of a metallic matter in an acid, as it has more affinity with the acid than with the metal, it seizes the acid, and obliges it to quit the metal, which therefore precipitates; because the metal has much less affinity than the alkaline salt has to the acid.

4. It happens sometimes that a principle, which, in consequence of the affinity we have been discoursing of, has been separated from another principle, may again resume its place with the principle, as it was originally, and dispossess the supervening principle. This affinity, which is called *reciprocal*, on account

of its reciprocal effects, takes place when the two principles which are alternately separated from the third principle by each other, have with this third principle, an almost equal affinity, and that their separation is procured by particular circumstances relative to some of their properties.

All that has been said concerning the affinities of three principles may be applied to affinities of four principles, due regard being had to the changes produced by the introduction of a fourth principle. It is evident, for example, that in place of one decomposition and one new composition, which can result from the different degrees of affinity of three principles, the affinities of four principles forming two new compounds, may, by a mutual change, produce two decompositions and two new combinations. This always happens when the sum of the affinities, which each of the principles of the two compounds has with the principles of the other, surpasses the sum of the affinities subsisting betwixt the principles forming the two first compounds. This sort of affinity, where there is a double exchange of principles, may be called *double affinity*. Examples of these affinities are often met in chemical operations and mixtures; and without a knowledge of them, it would be impossible to explain many singular phenomena of decomposition. For example, it happens often that two principles, neither of which could singly effect the disunion of the principles of a compound, because their affinities are each of them inferior to the affinity betwixt the principles of that compound, become nevertheless capable of procuring this decomposition when they act in concurrence. For this purpose, it is sufficient, as we have already said, that the sum of affinities which the two decomposing principles have with the principles of the body to be decomposed, should surpass the sum of the affinity betwixt the principles of the decomposing body, and the affinity betwixt the principles of the body to be decomposed. See examples of this play of affinities at the words BLUE (PRUSSIAN), and SALT (NEUTRAL ARSENICAL).

We shall pursue no farther these remarks upon affinities; because the affinities of bodies compounded of many principles are much less strong and less sensible in chemical operations; or because this science is not yet sufficiently advanced to have observed and distinguished them all. What we have said is sufficient to form just ideas on the theory of all the important phenomena which are exhibited by the fundamental experiments, and to conduct to many new discoveries.

#### XXI. A G A R I C. (t)

#### XXII. A G A T E. (u)

(t) AGARIC is a fungus growing on the trunk of the common larch tree, from which turpentine is obtained. Three-fourths of it is a resinous substance, and the remainder is a slimy mucilaginous earthy matter, so tenacious as scarcely by any method to be dissolved by water.

(u) AGATE is a flint variegated with different colors blended together, and sometimes with colored lines and dendritical figures, as the *mocha stone*, which is a variety of agate,

or with red spots, as the *fardea* or *St. Stephen's gem*, which also are varieties of this stone. For the chemical properties of agates, *see* EARTHS (VITRIFIABLE). By fire the color of a white agate, called *chalcidony*, was rendered whiter, and the color of a black agate was not changed. Colors may be given to agates, or their natural colors may be changed. Mr. du Fay, in the Memoirs of the Academy of Sciences, 1728, relates, that to *chalcidony* a saturated solution of silver in strong spirit of

**XXIII. AGGREGATION.** In order to have a clear idea of what chemists mean by the words *aggregation*, *aggregate*, *aggregated bodies*, we must attend to the difference betwixt what natural philosophers call *constituent parts* and *integrant parts* of bodies. The constituent parts are, properly speaking, the principles of bodies. These are substances differing in nature from each other, which, by their union and mutual combination, really *constitute* mixed bodies, which partake of the properties of their constituent parts. For example, the constituent parts of common salt are an acid and an alkali, which ought to be considered as the principles of this salt, at least as its proximate principles. *See PRINCIPLES.* As this acid and alkali are what really constitute common salt, and are the parts, to the union of which it owes its existence and properties, it is evident that the constituent parts cannot be disunited from each other, without destroying and decomposing it : so that after such a disunion, the salt will no longer exist, but only the acid and the alkali of the salt, which are very different from the salt, and from each other.

On the contrary, the *integrant parts* of bodies do not absolutely differ from each other ; nor do they differ, as to the nature and principles, from the body into whose mass they enter. By the integrant parts of a body are to be understood the smallest molecules or particles into which this body can be reduced without decomposition. We may conceive that a neutral salt, for instance, common salt, may be divided into molecules still smaller and smaller, without any separation of the acid and alkali which constitute the salt ; so that these molecules, however small, shall always be common salt, and possessed of all its essential properties. If we should now suppose that these molecules are arrived at their utmost degree of smallness, so that each of them shall be composed of one atom of acid and of another atom of alkali, and that they cannot be further divided without a separation of the acid and alkali, then these last molecules are those which Mr. Macquer in his Chemical Lectures calls *primitive integrant molecules*.

In the same manner that we conceive that a body may be divided into its primitive integrant molecules, without any change of its nature, or other alteration than a diminution of its bulk ; so we may also easily perceive, that if these pri-

mitive  
nitre gave a reddish brown color, to oriental agate a blacker stain, and changed the yellow spots of an agate to purple. The stone after the application of the metallic solution ought to be placed in the sun ; and the color may be rendered more intense by repeating the application of the solution. The liquor is reads so much on the stone, that neat designs cannot be made on it. Dr. Lewis proposes to remedy this inconvenience by covering the stone over with etching wax, and the lines intended to be stained cut through this ground, in the manner of etching copper plates. The colors given to these stones may be destroyed by fire or by aqua fortis ; and the colors thus destroyed by aqua fortis are recoverable by exposure to the sun. Agates and other

stones may be stained black by applying to them a solution of copper in aqua fortis, and afterwards exposing them to a red heat in a crucible. *See Lewis's Commerce of Arts.* Mocha stones may be imitated by moistening the smooth surface of an agate with a solution of copper, and on the middle of this surface setting an iron nail upright on its head. The iron absorbs the acid from the copper, and the copper forms ramifications. If the nail be then removed, and the corroded iron carefully washed off by dipping the stone in water, the vegetations may be rendered by a red heat, of a black color. These vegetations are not fixed in the stone, which ought therefore to be covered with a plate of crystal glass.



primitive integrant molecules, which are all homogeneous and of the same nature, and which are supposed separated from each other, should be brought to unite and combine together, no new body, that is, a body of different nature, will result from this union, but only a more considerable mass of the same body : that is to say, for instance, that if the primitive integrant molecules were common salt, their reunion would still form common salt, only in a mass so much larger, as there is a greater number of these molecules united together. But it is the union of these homogeneous parts, of these primitive integrant molecules, which modern chemists have called *aggregation* ; and they have called *aggregates* bodies considered as resulting from their primitive integrant parts, in opposition to the names *mixts* and *compounds*, which they have given to bodies considered as resulting from the union of their constituent parts, which are substances heterogeneous, and of different natures.

The name of integrant parts, which has been given to those whose union forms aggregates, agrees well with them ; because, in fact, this union is a kind of addition or integration (if such a word may be used) of a certain number of parts of the same kind, whence results a sum, or a whole.

It is very essential to observe on the subject of aggregation, that we should have a very false idea of it, and entirely opposite to chemical phenomena, if we understood by this word nothing but a simple juxtaposition of the integrant parts of bodies : for besides that, there must be a real adhesion and intimate union of these same parts with each other, so that they cannot be separated but by some force superior to that by which they are united. A heap of sand, for example, if we consider the grains of sand as its integrant parts, cannot be regarded as an aggregate, because these grains are only *juxtaposited*, and have no real adhesion together ; so that the resistance which they oppose to their separation can only proceed from their gravity, and is not the effect of adhesion, or tendency to each other.

In the second place, it is necessary to observe on the subject of aggregation, that the force of adhesion of the integrant parts of different bodies varies much, according to the nature of these bodies, some of them adhering very strongly, and others very weakly ; and that those which adhere weakly are generally the easiest to be dissolved, considering that the solution of a body, or its combination with another body of a different nature, cannot be effected but so far as the integrant parts of these bodies are separated, or their aggregation broken ; which is partly done by the operations of art, but chiefly by the action of menstruums.

All these considerations on the aggregation of bodies, although very simple in themselves, are of the greatest importance in the theory and practice of chemical operations. Becker and Stahl were the first who explained these ideas, which have been since illustrated and extended by the best modern chemists. See the words, *AFFINITY, COMPOSITION, SOLUTION, DECOMPOSITION, DIVISION of BODIES.*

**XXIV. A I R.** Air is a fluid invisible, inodorous, insipid, imperceptible to all our senses but the touch, and is considered as a simple elementary body, and primary principle, because it cannot be altered or decomposed by any known methods.

The air is always in form of a fluid, though perhaps that fluidity is not essential to it. But it is certain that no cold has ever yet been produced, natural or artificial, strong enough to deprive it of its fluidity.

We cannot flatter ourselves that we can have air, any more than the other elements, in perfect purity. On the contrary, it is always found mixed with more or less of foreign substances, proceeding from a perpetual exhalation of volatile matters, and particularly of water, with which it has even a certain degree of adhesion. (x)

The primary integrant parts of air, although certainly very small, yet are not so small as those of water, and even those of other liquids less simple, such as spirit of wine and oils: at least, these liquids pass easily enough through the pores of several substances, such as paper, the skin, &c. through which the air does not pass, or passes with difficulty.

The experiments of Mr. Boyle, and more particularly those of Dr. Hales, related in his *Vegetable Statics*, prove that most vegetable and animal matters contain a prodigious quantity of air; and scarcely credible, if the effects it produced were not so considerable and sensible. Chemical experiments also give us many occasions not only of observing these phenomena, but also of ascertaining the quantity of air disengaged, or absorbed in several operations. (y)

It appears that air, as well as other primary principles, is found in bodies in two different states: that is to say, that in certain bodies, and in certain circumstances, it is merely dispersed and interposed betwixt the integrant parts of those bodies, but without adhering to these parts, or at least adhering but very weakly. This air, which may be separated by means purely mechanical; such as the operations of the air-pump, compression, or shaking; and which besides possesses all its other properties; ought not to be considered as one of the elements of those bodies in which it exists. But that portion of air which cannot be separated from many bodies but by analysing them, and by employing such means of decomposition as chemistry furnishes; which, besides while it remains in those bodies, is deprived of one of its essential properties, its elasticity, which it does not recover till it is disengaged; this air, I say, ought truly to be considered as one of the elements or constituent parts of these bodies.

(x) Air not only *adheres* to water, as the text says, but chemically combines with it, and probably with many other volatile matters. The dissolving power of air, as of other menstrooms, is increased by heat; and hence upon an access of cold, the air deposits part of its water which it kept dissolved while its heat was greater. The water deposited becomes then visible, forming fogs, or condensing upon any cold body, as upon glass windows. This dissolving power of air is also effected by other circumstances besides heat: for we find that in equal heats air sometimes imbibes water faster than at other times. Dr. Gould found that vitriolic oil saturated with water by long exposure

to air, did sometimes lose and sometimes gain weight, according as the air was disposed to deposit or dissolve moisture. By what circumstances this dissolving power of the air is effected, and how these various states of the atmosphere affect the health of vegetables and animals, are subjects worthy of enquiry.

(y) Whether the permanently elastic vapors produced in distillations and other operations be really atmospherical air altered by its union with the bodies from which it is disengaged, has not been hitherto shewn. It has been called *fixed* or *fixable* air. See AIR (FIXABLE).

The properties of pure air, and which occasion many effects in chemistry, are :

1. Its *expansive power* ; that is to say, that it is capable of great rarefaction, and of occupying a space thirteen times larger than its original size, when it is exposed to the greatest possible heat. This great expansibility of air, added to the prodigious quantity of it which is disengaged in many chemical analyses and mixtures, occasions frequently violent explosions, against which an intelligent artist ought always to be on his guard. (w)

2. Its *compressibility* ; that is to say, that the effect contrary to that we have been mentioning, is produced upon it by means of cold and of pressure.

3. Its *elasticity* ; which is nothing else than the force with which it endeavours to resume its natural condition, when it is violently rarefied, compressed, or condensed ; and the effort which it makes for that purpose upon bodies which oppose its re-establishment.

4. Its *weight* ; which determines it to fall impetuously into all the spaces into which it can have access, and which are unoccupied by air, or more ponderous bodies. The experiments which demonstrate all these properties of the air are so numerous and decisive, that nothing is better known and illustrated in natural philosophy. On this subject may be consulted the works of Pascal, Boyle, Mariotte, Abbé Nollet, and, in a word, of all the experimental philosophers. It is only necessary to observe here, that the specific gravity of air is to that of water, nearly as 1 to 850.

5. The faculty which the air has of considerably *facilitating the evaporation* of volatile matters sublimed by the fire. It is a well-established fact in chemistry, that the access of air greatly accelerates all evaporations and distillations. We see, for example, that by directing the blast of bellows upon the surface of any volatile body evaporating by means of fire, as water, antimony, mercury, &c. that the smoke or vapors of these bodies are very sensibly increased. It is also certain that any distillation of a liquor, as of water, is much hastened, by directing upon its surface in the inner part of the alembic, the wind of a ventilator, as an English author has proposed. See DISTILLATION and EVAPORATION. (z)

(w) Air is expanded  $\frac{1}{3}$  of its bulk by the heat of boiling water. See the *History of the Academy of Sciences* 1699. Hales found that the air in a retort, when the bottom of the vessel was just beginning to be red-hot, was expanded to twice its former space, and in a white or almost melting heat it occupied thrice its former space or more ; and Mr. Robins, a very accurate experimental philosopher, found that air was expanded by the heat of iron just beginning to be white to four times its size. As greater expansions cannot be well estimated, I presume there is an error in that part of the text to which this note refers, where the air is said to be capable of expansion to thirteen times its ordinary bulk.

(z) Air accelerates evaporation by its dissolving power, which is indeed the principal or only cause of evaporation, if by that word we mean the escape of any fluid with less heat than is necessary to convert it into vapor in a vacuum. By the same power air may also accelerate distillations, in which the heat is sufficient to raise the fluid into vapor in a vacuum ; but if the air be cold, it will probably more impede the distillation by cooling the surface of the fluid, and condensing part of the vapor, than accelerate the escape of vapor by its dissolving power.

6. Lastly, the most singular property of air, and at the same time one of the most interesting in chemistry, is, that no combustible substance can burn without its access; and that the more strongly it is impelled against burning bodies, the more rapid is the combustion. Hence it follows, that as the most part of chemical operations cannot be performed without the assistance of fire, a constant current of air more or less strong, and in a certain direction, is necessary to produce the heat requisite in these operations. These currents of air are procured by bellows applied either to a forge, or to a melting furnace; or they are procured merely by the construction of the furnaces; which is done in such a manner, that by means of a space left in the upper part of the furnace, in which the heat keeps up a perpetual vacuum, the external air is determined and forced to enter by the ash-hole, to fill the vacuum above, and consequently forms a current which constantly passes through the fire, and which is so much more strong and rapid as the vacuum of the furnace above is greater. That is a fundamental principle from which general rules may be deduced, applicable to the construction of all possible furnaces. See BELLOWES, FORGE, and FURNACE.

Boerhaave, in his Treatise on Fire, and M. Gericé, Doctor of Physic, and Member of the Royal Academy of Berlin, who has also given a very large Dissertation on Fire, in a very good work, printed in 1741, entitled *Fundamenta Chymie Rationalis*, are of opinion, that the access of air is necessary to the combustion of substances; because, by its weight and spring, it keeps the flame constantly applied to the combustible body, and increases their contact.

But this theory does not sufficiently explain why combustible bodies may be kept red-hot in close vessels, without any consumption; because then it cannot be doubted but that the matter of fire is, by the movement excited during ignition, continually applied and even impelled upon the combustible body, without its burning or consuming. It has then all the appearance of a body burning and penetrated by fire, but it is by an extraneous fire that it is so penetrated; its own inflammable matter is not consumed, and rests unalterable in midst of a most intense fire.

However this be, it is very certain that the access of air is indispensibly necessary to maintain the combustion of bodies. But it is at the same time very difficult to find the true cause of this fact. The phenomena of combustion seem to prove, that the air materially concurs to the production of flame, and makes a part of it: for a given quantity of air can maintain only during a limited and determinate time, the combustion of a certain quantity of inflammable matter. If, for example, a lighted wax candle be placed under an inverted glass bell, which is joined exactly to its support, the flame of the wax candle subsists during a certain time, so much longer as the bell is larger, but constantly diminishing till at length it is extinguished; because the quantity of air contained in the bell being a determinate quantity, and not capable of being renewed, cannot serve but for a certain quantity of combustion. Another phenomenon worthy of observation in this experiment is, that after the extinction of the wax candle, a real vacuum is formed under the bell, which is then as strongly pressed upon its support, as if a vacuum had been made by an air-pump; which proves demonstrably that the air which it included

included, materially concurred to the production of flame; since, if it were not so, the air being greatly rarified by the heat within the bell, would, on the contrary, make an effort to raise itself, and would escape violently as soon as it could. (a)

If we reflect but a little on these phenomena, many questions occur very interesting, but at the same time very difficult of solution. In fact, does the air, which disappears in this experiment, form a new compound with the inflammable principle of the burnt body by a new combination? If it be so, what is this compound? and what becomes of it? or is the air itself a necessary pabulum or food of flame? is it decomposed by the act of combustion? If so, the air, is not a simple body: what then is the nature of its principles? and what becomes of them?

#### XXV. AIR (FIXABLE). (b)

XXVI. ALABASTER. The name Alabaster is given to stones externally resembling marble; of a hardness nearly equal; but inferior, and

(a) A partial vacuum only is formed by this experiment. Dr. Mayow found that  $\frac{1}{15}$ th part of the elasticity of the air in a close vessel was destroyed by the burning of a candle till it was extinguished; and Dr. Hales found this diminution of elasticity of air, by the same means, to be  $\frac{1}{15}$ th part. Dr. Hales also found that  $\frac{1}{15}$ th part of the elasticity of air contained in a close vessel was destroyed by burning sulphur. All the air contained in close vessels in these experiments was not, however, rendered fixable by the burning of the candle till it ceased to flame; for Mr. Cavendish found that  $\frac{1}{15}$ th part of fixable air was sufficient to render a quantity of common air unfit for the maintenance of the flame of a candle. See Phil. Trans. 1766.

(b) AIR (FIXABLE). By this term we mean those permanently elastic vapors which are disengaged from almost all bodies when decomposed by distillation, from vegetable and animal substances by fermentations, and from many matters during their combination with other substances.

This subject is one of the most interesting in chemistry. Little more was known concerning it, than that permanently elastic fluids were producible from the substances, and by the methods mentioned in the above definition; till lately that the phenomena attending the combination of these fluids with, and their expulsion from, those substances, together with some other properties, have been investigated by experiments. The author of this Dictionary seems to have been unacquainted even with those discoveries

which were published before this work. Of these the most important have been deduced by Dr. Black, from experiments so conducted and related, that his treatise may be considered as an excellent specimen of the best method of investigating and demonstrating chemical truths. See *Lectures Physical and Literary, published at Edinburgh*.

The discoveries already made enable us to explain many chemical phenomena. We shall have frequent occasions to supply the defects of the text in this particular, and to correct some errors that prevailed in the theory of chemistry till lately. The subject is still new, and much may be expected from further experiments.

Some fixable air is *inflammable*, and some is *not inflammable*. We shall treat first of the latter kind, to which the name *fixed*, or *fixable air*, has been more peculiarly applied.

An unflammable permanently elastic fluid may be produced by various methods, and from various substances. As the identity or diversity of the kinds of the several fluids thus variously obtained has not been yet ascertained, we shall mention what we know of each separately, distinguishing them only by the methods of their production.

1. A permanently elastic fluid may be obtained from *alkaline substances by combining these with acids*, or by *calcination*. Alkaline substances seem to have a power of combination with this fluid, and with it form compounds, some of the properties of which are different from the properties of these substances when uncombined. This power of combination

is susceptible of a similar, but less lively and sparkling polish. Some alabasters are white; and others are veined and colored, like marbles. When these stones are well polished, their semitransparency, which is more sensible than that of marble, gives them the appearance of agates.

is nevertheless weaker than that which alkaline substances have to acids, nor is it strong enough to resist the action of fire. Hence this fluid or fixable air may be disengaged from those substances by acids, or by fire when the alkaline substance is sufficiently fixed to receive a violent heat. When alkaline substances have been by any means deprived of this fixable fluid, and are exposed to an atmosphere in which particles of it float, they readily absorb it, unless they have been previously combined with some other substance, as an acid, with which they preferably unite, and again resume their former state. Hence all native alkaline substances are combined with this fluid. Thus, calcareous earth combined with this air forms the several masses of lime-stone, marble, chalk, and other stones and earths of this class. When any of these substances are deprived, by calcination or otherwise, of the fluid or air with which they are combined, they then become pure uncombined calcareous earth, or *quicklime*. Also fixed salts, obtained by incineration of vegetables are found to contain much fixable fluid, unless they have been perfectly calcined; and volatile alkali, obtained by distillation of animal or of some vegetable substances, is saturated with this fluid. The principal differences which have been observed betwixt these substances combined, or not combined with fixable air, are, 1. By combination with fixable air they are rendered susceptible of crystallization, which they are not when uncombined. Hence the uniform texture of marbles, calcareous spars, crystals of table or of mineral alkali, is extrication of this air. 2. By combination of alkaline substances with fixable air, the power of combination with all others which are incapable of expelling from this air, is diminished. Hence, by this combination, the solubility of calcareous earth in water is destroyed: hence fixed alkali is less disposed to deliquesce, or imbibe its moisture from the atmosphere: hence volatile alkali, which when combined is so strongly disposed to unite with water that it cannot

be obtained in a solid or concrete state, is rendered solid and crystallizable: hence the power of alkaline salts to dissolve oil is greatly diminished; so that soap-boilers find it necessary, in the preparation of soap, to deprive these salts, by quicklime, of all the fixable air with which they happen to be united: hence the causticity of calcareous earths is destroyed, and of alkaline salts is diminished; and hence, these substances when combined with fixable air are distinguished by the epithet *mild*, and when uncombined by the epithet *caustic*. 3. Alkaline substances combined with fixable air effervesce with acids, which they do not, when rendered perfectly caustic; this effervescence being caused by the fixable air, which is disengaged by acids from these substances.

This fixable air may be extricated from some alkaline substances by others, with which it has a stronger power of combination, and with which it does then actually combine. Thus mild volatile alkali may be deprived of its air, or rendered caustic by plying to it uncombined magnesia, fixed alkali, or calcareous earth, while these substances united with that air, and are rendered mild. Magnesia may be deprived of its air by caustic fixed alkali and calcareous earth; and lastly, mild fixed alkali be rendered caustic by quicklime or caustic calcareous earth, which is thereby rendered mild. Thus by adding a mild fixed alkali to lime-water, which is a solution of caustic calcareous earth in water, the calcareous earth will take the fixable air from the alkali, will become mild, consequently unsoluble in water, and hence will be precipitated.

Fixable air has a weaker power of combination than acids have with alkaline substances; hence these substances may be deprived of their fixable air by acids; and accordingly, when calcareous earth is precipitated from marine acid by a caustic alkali, it is found to be in a caustic state, or quicklime.

The quantity of fixable air contained in marble was found by Mr. Cavendish, (Phil. Trans. 1766) to be 1/100 of the whole, in

Naturalists disagree in their opinions about the kinds of stones which ought to be called *alabasters*. For some authors give this name to certain stones which are absolutely calcareous, while others give it to stones of a gypseous nature. Of the latter class of naturalists is Mr. Pott, who admits no calcareous alabaster, and

volatile sal ammoniac,  $\frac{1}{1000}$ ; and in crystals of salt of tartar  $\frac{1}{100}$ .

The specific gravity of this fixable air was found by Mr. Cavendish's experiments to be to that of water as 1 to 511, or to the specific gravity of atmospherical air, when this is 800 times lighter than water, as 1 to 1.

This fixable air is noxious to animals, and extinguishes flame. These properties probably do not proceed from its interception of common air, but from some peculiar quality; for Mr. Coxe found by experiments, that fixable air was more injurious to animals than a vacuum; and from Mr. Cavendish's experiments we find that 4 of fixable air, mixed with atmospherical air, occasioned the extinction of the flame of a candle.

2. A permanently elastic fluid or fixable air is produced by dissolving metallic substances in acids. From iron, zinc, and tin, dissolved in the vitriolic or marine acids, an inflammable air is produced, of which we shall treat afterwards. From all other metallic substances, and from these above mentioned dissolved in other acids, unflammable airs are produced. An air also adheres to metallic substances precipitated by mild alkalies or earths, which they receive from these precipitating matters, and which gives them greater than their original weight. To adhering air Dr. Black attributes the salinating property of the precipitate called *salminating gold*.

3. An elastic fluid or fixable air is produced by combining concentrated acids with oily and resinous substances, with spirits of wine and with water. These substances are the capable of absorbing the fixable air of alkaline matters. Thus, oil of olives was found to absorb an equal bulk of it; spirit of wine 2 times its bulk, with the heat of 46° of Fahrenheit's thermometer. Water also absorbed this air more copiously in cold than in hot weather. With a boiling heat, and even by exposure to common air during a few days, it parted with the air it had absorbed.

4. A fixable air is obtainable from animal, vegetable, and some mineral substances by distilla-

tion. By this method Dr. Hales procured from a cubic inch of deer's horn thirty-three grains of air, from Indian wheat  $\frac{1}{2}$  of its weight, from well-water  $\frac{1}{3}$ , from Pyrmont water  $\frac{1}{4}$ , from nitre  $\frac{1}{5}$ , from tartar  $\frac{1}{6}$ , and from salt of tartar  $\frac{1}{7}$  of the respective weights of these substances.

5. A fixable air is extricated from water merely by taking off the pressure of the atmosphere. An air may also be extricated by the same method from lime-water, which must be different from the air of alkaline substances, else it would precipitate the calcareous earth from the water, as Dr. Black has remarked.

6. Fixable airs are produced by the vinous, acetous, putrefactive, and probably by all other fermentations. Dr. Hales found that 42 cubic inches, of ale, which had been fermenting thirty-four hours, did continue to emit air from the 2d of March to the 9th of June following, sometimes more and sometimes less according to the heat of the weather; and that upon a sudden change of weather from hot to cold, it reformed air. The whole quantity of air emitted was 639 cubic inches. These airs are also deleterious to animals, and extinguish flame.

7. Atmospherical air is rendered unfit for respiration, or combustion, by having been inspired by animals or vegetables, and is therefore probably reduced to the same, or to a similar state with some of the above mentioned fixable airs.

8. Atmospherical air is rendered unfit for respiration or further combustion, by having assisted the combustion of ignited inflammable bodies. A considerable part also of its elasticity is destroyed by this combustion; for by burning a candle in a close vessel till it ceased to burn from want of fresh air, the air contained in the vessel lost, according to Dr. Hales,  $\frac{1}{10}$ th, and according to Dr. Mayow,  $\frac{1}{14}$ th part of its elasticity. These effects are not produced upon air merely by heat; for we find from Mr. Haverbee's experiments, that air was not altered by passing through a heated glass tube, but was rendered noxious to animals by passing through heated tubes

firmly maintains his opinion in his *Lithogcognosia* against Linnæus, König, Bruckman, and several other authors, who class alabaſter along with marbles and calcareous ſtones.

It cannot be doubted that the ſtone which Mr. Pott called alabaſter, and which he chemically examined, is actually gypſeous. His experiments evidently

of braſs and iron; glaſs being an incombustible ſubſtance, and metals, at leaſt thoſe called imperfect, being capable of calcination, which is a combuſtion, or diſſipation of their inflammable principle. Whence does this alteration of atmospherical air proceed? Is it that part of the atmospherical air is converted into fixable air, by combining with the phlogiſton or ſome part of the burning ſubſtances?

o A permanently elastic fluid or fixable air is produced by *deſagration of nitrous acid with any inflammable ſubſtance*. In this operation the acid diſappears, and an elastic vapor is produced. May we not thence infer, that the acid is converted by combination with ſome other ſubſtance, probably with the inflammable matter, or by decomposition of its own ſubſtance, into elastic vapor? The author of this Dictionary in the article *DETONATION OF NITRE* adopts the opinion of Stahl, that the exploſion of nitre with inflammable matter is produced by rarefaction of water contained in nitre or its acid. This rarefaction does contribute to the effect produced, but is not the ſole or principal cauſe: for the vapor of water is condensible by cold into a liquor ſimilar to the water from which it was formed, whereas the vapor of which we now treat is permanently elastic. Stahl did indeed maintain that the water was by this operation changed into air; but we have not ſufficient reaſons to believe the poſſibility of ſuch a conversion in any inſtance; and in this inſtance we know that the water of the nitre is, after the exploſion, condensed, and forms what is called a *chyle*. See *Clyſſus of NITRE*, and *DETONATION OF NITRE*.

This elastic fluid was found by Mr. Robins to occupy, when compressed by the atmosphere and reduced to the ſame heat, a ſpace equal to 250 times the ſpace occupied by the gun-powder before exploſion. And as the elasticity of air appeared from his experiments to be encreaſed four times by the heat of iron juſt beginning to be white; if this

fluid be equally affected by heat as air is, its elasticity in the inſtant of exploſion is about 1000 times greater than the preſſure of the atmosphere; a force ſufficient to produce the effects of gun-powder.

Theſe are the known kinds of permanently elastic fluids extricated from ſubſtances, in which they exiſted ſo combined, that their elasticity was either deſtroyed or counteracted by a ſuperior force. The properties of theſe fluids have not been ſufficiently investigated, to enable us to determine whether all or ſeveral of them be of the ſame or different kinds. Do not, however, the elastic fluids produced by combuſtion, and extricated from alkaline ſubſtances, ſeem to be of the ſame kind, ſince a cauſtic alkali may be rendered mild by expoſure to the former fluid? Are not theſe two elastic fluids probably of the ſame kind with that obtained from ſome metals; or, at leaſt, have they not ſome principle common to them all, ſince metals deprived of their fixable air, or of the principle which renders atmospherical air fixable, by calcination, or by ſolution in acids, may be reduced to their proper metallic ſtate by applying combuſtible ſubſtances; and ſince ſeveral inſtances are given, by authors, of the reduction of metallic calces by chalk, and other mild calcareous earths? Have not the fluids ſeparable from alkaline and metallic ſubſtances ſome analogy with acids? Like acids, they readily unite with, and effect the cryſtallization of thoſe ſubſtances. As a weaker acid is extricated from thoſe ſubſtances by a ſtronger, ſo is this air by all known acids. Are not the elastic fluids produced by the deſagration of nitre, and by the combuſtion or alkalization of tartar, and of other vegetable acid ſalts, formed from the acids of theſe ſubſtances combined with the inflammable principle? Whether theſe or many other conjectures, which might be made, be juſt or not, we may eaſily perceive that a judicious proſecution of this ſubject may tend to explain many important facts in chemistry.



demonstrate it. But, on the other side, it does not appear less certain, that the name *alabaster* has been very anciently given to stones undoubtedly calcareous. The greatest part of the antique vases and busts, although universally called alabaster, are of this kind. They are readily and entirely soluble in spirit of nitre with great effervescence, and are convertible by fire into quicklime.

The truth is, that sculptors and artists, who work upon marble and alabaster, seem to have given indiscriminately the name *alabaster* to stones which have only an external resemblance to each other; that is to say, to stones which, to the other external qualities of marble, join also a more crystalline and more transparent appearance. Thus these artists have confounded under one name stones of very different kinds; and hence, among those called alabasters, some are truly calcareous, and others entirely gypseous. Therefore if stones are to be named from their external appearances, we ought, in order to avoid a confusion of two substances entirely different, to admit two kinds of alabasters; one kind calcareous, of which the greatest part of vases and busts are made which are called alabaster; and the other kind gypseous, which is also used in sculpture, and is that which Mr. Port examined, and to which he assigns exclusively the name alabaster.

These difficulties being explained, chemists and naturalists are at liberty to take which side they please. They will always be understood when they distinguish in this manner the substances concerning which they write.

This being established, the kind of stone which may be called calcareous alabaster, has essentially all the properties of calcareous stones; for which reason, it is necessary to consult, upon this subject, the articles EARTHS (CALCAREOUS) and QUICKLIME. We shall only observe here, that it appears demonstrated, as M. d'Aubenton has advanced, that the differences observable betwixt calcareous alabaster and marble, proceed only from the different manners in which these

Concerning the antiseptic qualities of fixable air, see PUTREFACTION.

*Inflammable permanently elastic fluids* may be obtained by dissolving zinc, iron, or tin in marine or dilute vitriolic acids. 356 ounce-measures of air were obtained from an ounce of zinc dissolved in vitriolic acid, and also from the same quantity of zinc dissolved in marine acid: 412 ounce-measures of air were obtained from an ounce of iron dissolved in vitriolic acid; and 202 ounce-measures of air from an ounce of tin dissolved in marine acid.

This inflammable air was not absorbed by water, or by fixed or volatile acids.

Like other inflammable substances, it is only combustible by means of atmospheric air, of which it requires an exact quantity for that purpose.

It was found by experiment to be eleven times lighter than atmospheric air, when the weight of this was to that of water as

one to 800. Hence the quantity of air obtained from zinc, as above mentioned, was nearly  $\frac{1}{800}$ th part of the semi-metal.

An inflammable permanently elastic air is also producible from putrefying vegetable and animal substances. One grain of this air was obtained from 7640 grains of putrefying gravy broth, which contained about 163 grains of solid matter. The loss of weight sustained by this broth was much greater. The remaining part must have been according to Mr. Cavendish (from whose paper on factitious air, Phil. Trans. 1766, all the above mentioned facts on inflammable air are copied) unflammable fixable air, and some matter which communicated color and smell to soap-leys.

An inflammable permanently elastic fluid is frequently observed in mines, and is dangerous to miners. These fluids are called *Damps*. See the article DAMPS.

two substances are formed; marble being of ancient formation, and the product of a deposition of calcareous particles accumulated upon each other in banks and large masses: while calcareous alabaster is formed also of calcareous particles, but in the way of filtration; and of *stalactites*, of which large enough masses are found to make vases, busts, and even statues. This difference in the formation of these two matters is sufficient to explain the cause of the greater transparency of calcareous alabaster. In fact, if a piece of calcareous stalactites be cut and polished, no difference can be perceived betwixt it and works made of calcareous alabaster.

As to the stone called *gypseous alabaster*, it has all the properties of gypseous stones, and therefore it is necessary to consult upon this subject the articles GYPSUM and PLASTER.

**XXVII. ALCHEMY.** This term has been employed by the pretended adepts, and by searchers after the philosopher's stone, to distinguish that kind of chemistry the knowledge of which they flattered themselves was reserved for them alone. The adepts consider chemistry as a vulgar science, which scarcely contains the first elements of the mysterious science of alchemy. But hitherto they have produced nothing which, in the judgment of sensible men, can give the least grounds to such a pretension. True chemists consider alchemy as an imaginary science, and those who are devoted to it as persons who, from want of better instruction, quit a reality for the sake of a shadow.

**XXVIII. ALEMBIC.** An alembic or *still* is a vessel employed in distillations. There are several kinds differing from each other, either as to their form, or the matter of which they are composed.

The most frequent use of alembics is for distillations of very volatile principles drawn from several substances, particularly from vegetables. When the principles intended to be procured by distillation have no considerable action upon metals, and when they are susceptible of rising with a degree of heat which does not exceed, or but little, the heat of boiling water, copper alembics well tinned in their internal surface are employed.

The most convenient of these alembics, and which may be employed for many kinds of distillation, are composed of the following pieces. The first is a kind of pot designed to contain either the matters intended for distillation, or water, in which is immersed another smaller vessel of the same form, and made to contain the matters intended for distillation by the water bath. These pieces of the alembic are called in general *cucurbits*, because formerly they were of an oblong form, upright, contracting themselves in their upper part, and diminishing into a kind of neck, which made them resemble a cucurbit, or gourd, or a bladder, by which latter name also they have been distinguished.

The cucurbits of copper alembics used now have no resemblance to this form: on the contrary, they are broad, not very deep, and wide. This new form of cucurbits is much more advantageous, as by it the distillation is much accelerated, with equal heat. The reason of this is, that the quickness of distillation is always proportionable to the quickness of evaporation; and that as evaporation is always made at the surface of bodies, the more surface these bodies present, the more quick and easy will be the evaporation. But the broad and wide form of modern cucurbits is infinitely more proper for the expelling of much

much surface of the bodies contained, and particularly of liquid bodies, than the form of the ancient cucurbits, which were high and strait.

The first of these two pieces is of copper, that it may resist the action of the fire: the second is generally of tin, and ought to be so shaped, that it can enter exactly into the former piece, and that they should fit so well as to render any luting unnecessary.

There ought to be a small pipe or neck at the upper part of the first piece, which may be exactly closed, and through which water or other fluid may be introduced at pleasure.

The third piece of the alembic is called the *capital*, because it is a kind of head. This piece has the form of a hollow cone. It is furnished with a gutter or channel, which is placed along its inner and lower circumference.

This capital has also in its lower part a kind of neck, which ought to enter so exactly into either of the two former pieces, as no luting shall be necessary. Lastly, it ought to have a pipe, called the *beak*, which opens inwardly into the gutter.

This beak ought to be from fifteen to eighteen inches externally, and so inclined, that it shall make with the neck of the alembic an angle of about sixty degrees.

The fourth piece of a copper alembic is called the *refrigeratory*. It is a kind of bucket, surrounding the capital, to which it is exactly foldered in its lower part. In this, near its bottom, is inserted a cock. The use of the refrigeratory is to contain cold water to facilitate the condensation of vapors circulating in the capital. Its cock serves to empty the water when it is become too hot, that it may be supplied with cold.

As in copper alembics the refrigeratory and capital are joined, they may be considered as making only one piece. However, it is necessary to distinguish them; first, because their uses are very different; and, secondly, because the refrigeratory is not essential to the alembic. Several chemists, good operators, are doubtful concerning its utility, particularly since the custom was introduced of applying worms to alembics.

The *worm* is a long, tin, spiral pipe, included in a copper bucket, so that its upper and lower extremities shall come out of the bucket by two holes, round which they are well foldered. The upper extremity of the worm receives the beak of the alembic, and its lower extremity enters into a receiver fitted to it. The bucket containing the worm is filled with cold water, which cools and condenses the vapors passing through it. The principal advantage which this refrigeratory has over that surrounding the capital, is, that it is not subject to retard or even to stop the distillation, as the latter one is: for this inconvenience has been observed to happen, whenever the capital of the alembic has been exposed to a certain degree of cold. There is in M. Beaume's Elements of Pharmacy a very exact description, and a good engraving of a copper alembic with its worm.

The alembics described are of great use for the distillation of the *spirits rectifier* of vegetables, of their *distilled waters*, of their *essential oils*, of pure *acids*, *spirits*, of *spirts* charged with the odoriferous principles of plants, and also for many other distillations of this kind. But as it is frequently necessary to distill in alembics acid and saline liquors capable of attacking metals, glass alembics are employed

employed for such distillations: and these are generally composed of only two pieces, namely, a cucurbit, and a capital, which is fitted above and joined by luting. There are glass cucurbits, high and strait, which may be useful for the distillation of certain very volatile substances. Others are made shallow and broad, and these have the same advantages from their form as the metal ones have.

To avoid the luting of the capital with the cucurbit, these glass alembics have been made of one entire piece. The capital of these alembics, which are of crystal glass, ought to have an opening at its top, which may be exactly closed with a crystal stopper ground with emery. This opening is intended for the introduction of matters to be distilled, and for the extraction of the residuums after distillation. These alembics of one piece, although sometimes convenient, are seldom employed on account of their dearth, and of the difficulty of introducing, and of extracting solid matters.

There are also made cucurbits of stone-ware, and of glazed earthen ware, which are useful in many cases. See at the word DISTILLATION several observations relative to the form and matter of alembic. See Plate 1.

**XXIX. ALKAHEST.** This is a name given by ancient chemists to a pretended universal menstruum. Such a menstruum either does not exist, or else there is not any body in nature which may not become an alkahest. For although certain substances have not hitherto been combined with others, the daily discoveries in chemistry of combinations formerly believed impossible, seem to prove, that by certain management, and certain circumstances, any substance may be combined with all others; or, in other words, that all bodies may be dissolved by any single substance. (c)

**XXX. ALKALESCENT.** This word is employed to denote a matter slightly alkaline, or which begins to turn to the alkaline and putrid fermentation.

**XXXI. ALKALI (FIXED).** Fixed alkali is a substance composed of acid, of earth, and of a little phlogiston; and whose principles have to each other a weaker adhesion, than the principles of any acid have to each other. There are several kinds of saline alkaline substances. These are vegetable alkali, mineral or fossil alkali, and volatile alkali. They are all called by the general name *Alkali*, because the following properties are common to them all.

1. Alkalies may easily be obtained dry and concrete, and freed from all water unnecessary to their saline essence. (d) When they are in this state,
2. They produce heat by adding water to them.
3. They attract the moisture of the air, and deliquesce into a liquor. (e)
4. They change the color of syrup of violets into green, whether they be dry or fluid.

(c) Kunkel very well shews the absurdity of searching for an universal solvent by asking, "If it dissolves all substances, in what vessel can it be contained?"

(d) Volatile alkali retains water so strongly that it cannot be obtained dry, unless by combining it with fixable air, and then it becomes crystallizable. The fixed alkalies

may be rendered dry by application of heat, but are only crystallizable by help of fixable air. See AIR (FIXABLE).

(e) Mineral alkali does not deliquesce by exposure to air; but on the contrary, when crystallized, it becomes dry, and loses the water which is necessary to its crystallization.

2. They

5. They have an acrid, burning taste, so much stronger as they are purer and dryer. This taste has something *urinous*; and hence they are called by some chemists *urinous salts*. They are also called *lixivial salts*, because the method of obtaining fixed alkalies consists in lixiviating the ashes of certain vegetable substances.

6. They partly exhale with water, particularly when boiled in open air.

7. When they are dried and re-dissolved, some earth is always separated from them.

8. They may be fused by a moderate heat.

9. When fused; they dissolve all earths.

10. When added to earths and particularly to those called vitrifiable earths, and exposed to a sufficient degree of heat, they and the earths become glass. See VITRIFICATION.

11. When added in a large proportion to the earths, with which they are fused or vitrified, they communicate to these earths all their own properties. See LIQUOR OF PLINTS.

12. They effervesce and unite with acids to the point of saturation more perfectly and more intimately than pure absorbent earths, and from this union result different neutral salts.

13. They decompose all salts with bases of earths, metals, or volatile alkali. They separate these bases, and unite with the acids of the salts, with which they form new neutral salts. This is an example of stronger affinity, from whence result a new decomposition and a new combination.

Alkaline salts being substances pretty simple, as well as acids, are powerful solvents. They are capable of combining not only with all acids and with all earths, as we have said, but also with sulphur and with oily matters. With sulphur they form a sulphureous soap, soluble in water, called *liver of sulphur*; which *see*.

With oils, fat, resins, &c. they form compounds, which have been called *soaps*. In each of these combinations, the alkali is a medium by which the inflammable substance, naturally insoluble, and even immiscible in water, becomes miscible and soluble in that liquid. See SOAP.

These saline substances can act also upon spirit of wine, when they are deprived of all the water unnecessary to their essence as salts. Alkalies, in that state, applied to spirit of wine, first deprive it of its superfluous water; afterwards, when in a proper proportion, they act upon its own substance, by combining with it, and causing several alterations, and even a decomposition of its parts. See SPIRIT OF WINE (TARTARISED), and TINCTURE OF SALT OF TARTAR.

Lastly, alkalies act upon metallic substances with more or less facility, according to their natures, and the different means employed; which shall be mentioned under the several articles of the alkalies and metals.

N. B. All that has been said above concerning alkalies, may be applied to all the several kinds of alkalies, even to those called *volatile*, excepting those properties which depend upon fixity. Hence this article is applicable to alkalies in general. But it is necessary to observe, that a very just idea cannot be formed of these generalities, without entering into the details of what concerns the several kinds. See for the *affinities* of fixed alkali, and for its *medicinal virtues*, the word ALKALI (FIXED MINERAL).

**XXXII. ALKALI (FIXED VEGETABLE).** This name is given to all fixed alkalies obtained by burning any vegetable substances, and which have not the properties of the alkali, which is the basis of common salt, which has been called the alkali of common salt, the *marine alkali*, *mineral* or *fossil alkali*.

The common method of obtaining fixed alkalies from vegetable substances, consists in burning these substances freely and in open air, till they be reduced to ashes. See COMBUSTION of PLANTS. After which these ashes are lixiviated with very pure water, till the water comes from them insipid. This lixivium is evaporated to dryness; and what remains is the fixed alkaline salt of the plant, which may be deprived of its superfluous water and superfluous phlogiston by calcination with a long and gentle fire.

Fixed alkalies obtained from any vegetable matters when well prepared and carefully purified by means hereafter to be described, are all exactly alike, and have the same properties; so that they are only one and the same kind of saline substance. But as it is very difficult to procure this salt in its utmost degree of purity, and as, in this respect, there is a difference betwixt those obtained from different vegetable matters, some of them being naturally purer or more easily susceptible of purification than others; and further, as sufficient attention has not been given to the means of perfectly purifying these alkalies, two inconveniences have happened. The first is, that several chemists have imagined that there was an essential difference betwixt alkalies obtained from different plants: and the second is, that other chemists have attributed to alkalies in general, several properties not belonging to them as alkalies, but to certain foreign substances adhering to them. We here consider the vegetable alkali perfectly purified: and after we have enumerated its principal properties, we will treat of its origin, of its formation, and of the means of purifying it.

Fixed vegetable alkali has all the properties related under the article **ALKALI (FIXED)**.

It is solid or concrete, like an earthy substance; of a fine white color; without transparency, or crystalline and regular shape, because, in fact, it is not susceptible of crystallization (*f*); of no smell while it is dry, but of a slight lixivial smell when moistened with water. It has a violent, sharp, burning, caustic and urinous taste; that is to say, that when put in the mouth, it discovers a taste of putrescent urine, which is caused by the disengagement of volatile alkali from animal substances.

Here it is proper to observe, that when it is required to taste fixed alkali, it is convenient to dissolve and dilute it in much water, which only lessens its strength without altering its character: otherwise, the tongue might be blistered, because calcined alkali is powerfully caustic, and quickly corrodes and destroys all animal matters. (*g*)

Fixed alkali, exposed to air, attracts moisture, with which it resolves, or deliquesces into a white transparent colorless liquor like pure water. Fixed alkali

(*f*) Fixed vegetable alkali does not so readily crystallize as mineral alkali does. It is nevertheless crystallizable by exposing it to fixable air, with which it combines and forms crystals. See AIR (FIXABLE).

(*g*) The cause of this is, that by calcination fixed alkali is deprived of a part of its fixable air, and is thereby rendered more soluble, and consequently more caustic. See AIR (FIXABLE).

attracts thrice its quantity of moisture, according to Gellert. *Chemie Metallurgique*, Tom. 1. p. 26.

The same thing happens if it be purposely dissolved in water. But in this latter case, at the first instant of the mixture, a pretty strong heat is excited, by the activity of the union of alkali and water. This heat, however, is much less than what arises from the mixture of concentrated vitriolic acid and water.

Every time that fixed alkali is dissolved in water, a portion of indissoluble matter remains. If the solution be filtered, it passes very clear: but after some time, it begins to be turbid, and small flocks are formed in it of a matter which falls to the bottom of the vessel, and cannot afterwards be redissolved. This matter is of the same nature as the first substance which we observed remains undissolved; and is nothing else than a portion of the earth of the alkali, which is separated every time that the salt is calcined and dissolved. The part which at first passes through the filter, and which afterwards renders the liquor turbid, is that part which was the most attenuated, and most adhering to the alkaline salt. This earth thus separated, is no longer in a saline state, and consequently becomes indissoluble in water like pure earths.

Alkali dissolved in the smallest possible quantity of water, forms a liquor less fluid, more thick, and unctuous than pure water, and which passes with more difficulty through the filter, from the quantity of saline matter with which the water is charged. When it is touched and rubbed betwixt the fingers, it appears to have a fat and oily nature; which proceeds from the greasy particles of the skin dissolved by it. These properties have occasioned it to be called, but improperly, an *oil*, by ancient chemists. See *OIL of TARTAR*. It ought to be called the *Liquor of alkaline salt*.

Dry fixed alkali, exposed to a moderate fire, that is, a little more than cherry red, sustains its action pretty well, altho' it fuses, and diminishes in quantity. But by a very violent fire, the greatest part of it is dissipated in vapors, or even all of it, if the heat be sufficiently long and intense. It is easy to be convinced of this by observing the pots in which glass is melted in glass-houses. Above these pots a perpetual smoke may be seen, which can proceed only from the fixed alkali which enters into the composition of glass; the other matters which enter into that composition being infinitely more fixed than it.

Fixed alkali is a very powerful solvent. In the dry way, and by help of proper heat, it dissolves all calcareous, vitrifiable, argillaceous, gypseous, and metallic earths; and in certain proportions, and nearly in equal parts, it changes most of these into different kinds of hard, solid, and transparent glasses. See *GLASS, VITRIFICATION, CRYSTAL-GLASS*.

When a third or fourth part only of earth is added to it, they more readily fuse, and unite together: and as the alkali is the prevailing principle in the new compound which results from this union, so its properties also prevail. Hence it renders the earths so dissolved, soluble in water; and in acids, susceptible of attracting the moisture of the air, &c. See *LIQUOR of FLINTS*.

The alkali appears to have no action by the humid way upon substances purely earthy; but it has upon quicklime, to which it gives, and from which it receives, very singular alterations. When it is liquid, and treated with this sub-

stance, it becomes infinitely more caustic and more fusible than it was before. See LIXIVUM of SOAP-BOILERS, CAUTERY. (b).

Fixed vegetable alkali unites with the vitriolic acid violently and with great effervescence. The union of these two saline substances is very strong and very intimate; and from thence results a perfect neutral salt, which is *vitriolated tartar*. See TARTAR (VITRIOLATED).

With nitrous acid it forms *nitre*, a neutral crystallizable salt, the properties of which see under the word NITRE.

With marine acid, fixed vegetable alkali forms a particular kind of common salt, resembling in many respects the natural common salt, but differing from it in others, and chiefly in its taste, which is much less agreeable than that of common salt. The differences betwixt these two salts are caused by the difference of their alkaline bases, natural common salt having for its basis a particular kind of fixed alkaline salt, which differs considerably from the fixed vegetable alkali. The kind of common salt formed with this latter alkali and marine acid is called *regenerated common salt*, or SALT (FEBRIFUGAL) of SYLVIVS. See that article.

Fixed vegetable alkali unites also very well with vegetable acids, and with them forms different neutral salts, according to the nature of these acids. With the acid of vinegar, it makes a neutral deliquescent salt, of a very pungent taste, called, *regenerated tartar*, or *Terra foliata tartari*; see these words. With the concrete vegetable acid, or cream of tartar, it forms a neutral crystallizable salt called *tartarified tartar*, or Salt (*vegetable*); which see.

Lastly, fixed vegetable alkali unites also and forms true neutral salts with any substances, which, though not pure acids, do however act as acids with relation to alkalies. Such is the sedative salt, with which this alkali forms a particular kind of *Borax*. See BORAX and SALT (SEDATIVE). Such also is arsenic, with which it unites to the point of saturation, and forms a very singular, neutral, crystallizable salt, the properties of which were first observed by M. Macquer, who gave it the name of *neutral arsenical salt*. See SALT (NEUTRAL ARSENICAL).

Fixed vegetable alkali dissolves sulphur in all its substance; that is, it unites with both the acid and the phlogiston of which this mineral matter is composed. It only diminishes the adhesion of these two constituent parts of sulphur. This union of alkali with sulphur may be made in the humid way and in the dry way; but much better in the latter. Hence results a particular saponaceous body, called *liver of sulphur*, which is a powerful solvent of all metallic substances. See LIVER of SULPHUR.

Metallic substances are capable of being attacked and dissolved by pure alkali. Some of them, such as iron, and particularly copper, need only to be digested in the liquor of alkaline salt, to be perfectly dissolved. Most of the others require to be previously dissolved by acids: but by means of this solution in acids they become very soluble in alkali. For this purpose it is necessary to pour some drops of metallic solution into a very strong liquor of alkaline salt: at first a precipitate is formed, which disappears when the liquor is agitated; thus the

(b) The causticity which alkaline salts acquire by being treated with quicklime, is occasioned by this substance depriving them of fixable air, to which it has a stronger power of combination than they have. See AIR (FIXABLE).



acid metallic solution is to be continued to be poured in at different times into the alkaline liquor, till this latter cannot any longer dissolve the precipitate.

All metals are not by this method dissolved with equal facility, and in equal quantities by fixed alkali. The lunar metals, namely, silver, mercury, and lead, are dissolved by it with more difficulty and in less quantity than the solar metals, such as gold, platina, tin, copper, and especially iron. This last metal gives to the alkali while it is dissolving a beautiful saffron color, approaching to red. This solution of iron by alkali was first published by Stahl, and by him called *martial alkaline tincture*. See TINCTURE (MARTIAL ALKALINE) of STAHL.

It is proper to observe upon the subject of the solubility of metals in fixed alkali; 1. That in order to its success, it is very necessary that the previous solution of metal in an acid should be very acid, and very far from the point of saturation. In whatever manner the operation is done, it always fails in making the martial alkaline tincture of Stahl, if a very saturated solution of iron in nitrous acid be employed. M. Macquer and Mr. Beaumé have ascertained the necessity of this management, which is not observed by Stahl or any other chemist.

2. Most of these metallic solutions in alkali preserve their limpidity only during a certain time: after which they become turbid, and a deposition is then formed, of the same color as the solution. This deposition is nothing else than a portion of the dissolved metal which separates from the solvent, as happens to several solutions of metals in acids.

3. A very illustrious chemist recommends for the solution of metals in fixed alkali, particularly of gold, silver, mercury, zinc, and bismuth, an alkali phlogisticated and fit to make Prussian blue. But this is the precise way to fail in the operation. This able chemist has been led into error by some of those circumstances, which are but too frequent in chemistry, and against which it is impossible for the most intelligent persons to be always guarded. Some details upon this subject may be seen under the articles BLUE (PRUSSIAN), and TINCTURE (MARTIAL ALKALINE) of STAHL.

By fusion and by the dry way, fixed alkali dissolves and vitrifies all metallic calxes, or earths deprived of phlogiston; perhaps even it is capable of dissolving the metals uncalcined.

Fixed vegetable alkali unites easily with oils and oily substances, and communicates to them its property of mixing well with water. With them it forms saponaceous compounds, partaking of the properties of oil, and of those of alkaline salt, as has been said under the article of alkali in general. See the word SOAP.

As to the origin of fixed vegetable alkali, it is disputed whether it exists ready formed in vegetables previously to their combustion, by which it is obtained, but which in this supposition does only disengage substances which envelope and disguise it; or whether vegetables contain only the materials proper for its formation, which consequently takes place in the act of burning, and whether it be, properly speaking, produced by fire.

There are reasons for and against these two opinions; and they are so strong on both sides, that there are grounds to believe that both of them are true; that

is to say, that the fixed alkali obtained after burning a vegetable, did partly exist ready formed in that vegetable before it was burnt, and that the other part was produced by the very act of combustion.

The proof of the former part of this proposition is, that from most plants neutral salts whose bases are fixed vegetable alkali, such as vitriolated tartar and nitre, may be actually obtained without burning. And still more : M. Beaumé, upon a particular examination of the plant called *coronilla folis*, found that this plant when well cultivated furnished not only a very considerable quantity of perfect nitre, very susceptible of crystallization and detonation, the base of which consequently was fixed vegetable alkali, but also a large quantity of this alkali, disengaged from any acid, well distinguished, and possessed of all its properties. An alkali then does exist in vegetables previous to burning. It remains to be examined whether this alkali existing in plants previous to burning, be truly one of their principles and constituent parts, or only a foreign and unnecessary substance. What renders the latter opinion probable, is that the quantity of alkali in plants, whether disengaged or united to an acid in neutral salts, is very variable, and that it appears to depend solely on culture and on the nature of the soil : so that it frequently happens, that the same plants which contain much alkali when these two circumstances favor its introduction, contain none at all in contrary circumstances.

As to the second proposition concerning the origin of fixed vegetable alkali, which is, that a great part of this alkali is produced and combined by the act of combustion, it is established by several proofs seemingly incontestable. The observation of the circumstances concurring to the production of alkali by burning, demonstrates that this alkali is in great measure formed by the vegetable acid, which, during the deflagration of vegetables, combines in a particular manner with a portion of their earth and inflammable principle.

The following observations will render this truth evident.

1. When vegetables capable of furnishing ashes containing much alkali, are decomposed by other means than combustion, scarcely any other saline matters are obtained from them but fluor acids, or what are properly called essential salts, which are nothing else than concrete acids rendered solid by a portion of oil and earth.

2. When vegetables are deprived of a part of their acid by distillation, or by extraction of their essential salts, the quantity of fixed alkali obtained from their ashes is as much less, as the quantity of acid previously taken away was greater.

3. The matter of extracts containing almost all the acid of the vegetables used for that extraction, and the essential salts of vegetables are, of all vegetable matters, those which furnish the greatest quantity of fixed alkali by burning in open air. The concrete acids particularly are changed by this process almost entirely into fixed alkali. A striking example of this is seen in the combustion of tartar, which is one of those concrete acids.

4. Oils and oily concretions, which contain little acid and earth, leave after burning a scarcely sensible quantity of fixed alkali.

5. Plants which contain a very volatile acid, and those from which an acid is obtained by distillation, such as mustard seed, leave also in their ashes but an almost insensible quantity of fixed alkali.

6. All vegetables, even those which in their natural state furnish ashes containing much fixed alkali, when burnt, after their acid has been altered by a complete putrefaction, leave ashes entirely free from alkali.

We cannot therefore but conclude, after having attended to these facts, that the greatest part of the fixed vegetable alkali is produced from the acids of vegetables.

We ought also, after what has been said on the origin and production of fixed alkali, to perceive the reason, why vegetable matters, which have undergone decoctions or long macerations in much water, as floated wood, leave but little or no alkali in their ashes. The water has dissolved and carried off either the alkali ready formed, or their acids and essential salts, which, as we have seen, are the principal materials of its composition.

Fixed alkali prepared by the incineration of vegetable substances, and by lixiviating and evaporating to dryness, is very far from the degree of purity requisite in exact chemical experiments.

It is almost always altered; 1. By some remaining inflammable principle, which could not be entirely consumed during the burning; 2. By a portion of superabundant earth; 3. By the mixture of different saline matters as fixed as itself, which partly or entirely elude the action of the fire. These saline matters are either some neutral salts, which are frequently found in plants; such as vitriolated tartar, Glauber's salt, common salt, and sometimes a little nitre; or a portion of fixed mineral alkali. 4. As iron is diffused in almost all bodies, and particularly in greater or less quantity in the ashes of vegetables, as Mr. Geoffroy has proved; and further, as iron is very soluble by fixed alkali; this saline substance is subject to be altered by mixture with iron.

Fixed alkali is discovered to be phlogisticated, or altered by a superabundance of inflammable matter; 1. By its color not being perfectly white, and by its lixivium or solution in water being more or less yellow, or red instead of being absolutely colorless; 2. By the smell of its lixivium, which is always so much stronger, as it is more phlogisticated; 3. By its degree of causticity, which is always so much less as it retains more superabundant inflammable matter; 4. Lastly, by its property of forming Prussian blue, by precipitating solutions of iron in acids, when it is much phlogisticated. See upon this last article, BLUE (PRUSSIAN).

There are two methods of purifying fixed alkali thus altered, that is, of depriving it of all the superabundant inflammable matter it contains. The first is by calcination, according to the general rules and with all the attentions necessary to be observed in calcining by fire. See CALCINATION.

The second method of purifying fixed alkali from superabundant inflammable matter consists in applying to it a body on which it cannot act, and which has a stronger affinity than it with this inflammable matter. M. Beaumé first practised this second method. This able observer, having perceived that when he evaporated in silver vessels red and phlogisticated alkaline lixiviums, these vessels were more and more tarnished, till at length the surface of the silver became quite black, and that the lixivium lost its color in proportion as the silver acquired it, carried this experiment as far as possible; and at length, by renewing the surface of the silver contiguous to the alkaline lixivium, he deprived this lixivium of all its color, and rendered it entirely white. This lixivium being then

then evaporated to dryness, furnished an alkali very white, very caustic, and free from all superabundant phlogiston. Besides the practical method of dephlogisticating alkaline salt, which this experiment suggests, it also confirms a truth demonstrated by M. Macquer in his theory of Prussian blue; namely, that metallic substances may be charged with a superabundant quantity of inflammable matter, and that they are capable of taking it from fixed alkali by the humid way. *See BLUE (PRUSSIAN).*

The second substance which alters fixed alkali is a superabundant earth. As this earthy substance is not soluble in water when alone, and as it has but a weak adhesion to the alkali, it may be easily separated by drying it once or twice by solutions and filtrations. But this purification must not be carried too far, because the alkali itself is capable of decomposition by this method, in detaching itself at every drying or calcination from a part of its earthy principle.

As to the saline matters which by their mixture alter the purity of the fixed alkali, they can be separated by no chemical process but by crystallization. This method is founded on the incapacity of the alkaline salt to crystallize, and on its property of decomposing and of converting into crystallizable salts, all uncrystallizable and deliquescent salts with which it may be mixed. It is then necessary to evaporate to the convenient point, the alkaline liquor from which these foreign salts are to be separated, and to let it cool at several different times to favor the crystallization of those salts which are best crystallized in the cold, or to continue the evaporation for those salts which, like common salt, can only be crystallized by this method. *See CRYSTALLIZATION.* But it is manifest, that this method, however carefully performed, is incapable of procuring a perfect separation of all the extraneous salts from the alkali; since while this continues fluid, it always remains mixed with a small quantity of crystallizable salts, which are dissolved by part of the same water which keeps the alkali fluid; and that the separation by crystallization cannot take place but when all is evaporated to dryness. It is then impossible to separate completely from the alkaline salt, the last small portions of extraneous salts with which it was mixed. Notwithstanding this, the degree of purity to which the alkaline salt may be brought by this method is considerable, and sufficient for most of the operations of the arts, and even for many operations in chemistry.

It is still more difficult to purify the alkali from iron. No practical method is known for this purpose. When therefore a very pure alkali is required, it is proper to choose such substances as furnish a salt the least impure. For in this respect there is a great difference betwixt the substances from which it may be obtained, as will appear when we enumerate summarily the several alkalis most frequently used.

Fixed alkali being of great use, and much employed in arts, as it is the basis of soap and leys, and much used in dyeing, making of glass and saltpetre, is procured from matters which furnish a great deal of it, and at a small expence.

The most common alkali, and at the same time the least pure, is that of the ashes of common hearths. These ashes are employed for lixiviums, in the manufacture of saltpetre, and in glass houses where common bottle-glass is made.

In the Northern countries, where wood is plentiful, it is burnt on purpose, as well as many plants, to procure from their ashes a strong but very impure alkali, called *Pot-ash*. This alkali is always much phlogisticated, and contains many of the saline matters above-mentioned. Pot-ash is employed for the purposes related. It is also used by dyers in some of their operations. Pot-ash may be purified so far as to become a very good alkali by the methods mentioned. (i)

The dregs and leys of wine being dried and burnt, leave ashes abounding in alkaline salt, called in French, *cendre gravelée*. This alkali is not only in great quantity in these ashes, but likewise when the matters furnishing it are properly and carefully burnt, it is the purest of all those which are in commerce. If

(i) The great consumption of pot-ash renders it a matter of importance. We shall therefore describe the methods of preparing it.

In some parts of Germany it is prepared from the same wood of which charcoal is made. A number of tubes, made of plate iron, or of copper or brass, are so disposed in the pile of wood intended to be burnt into charcoal, that the water, acid, and oil, which are obtained in ordinary distillations, shall, when separated from the wood by fire, pass through these tubes into buckets placed to receive these liquors. The oil is then to be separated from the acid liquor, which is then to be boiled in copper or iron vessels, and the residuum dried and calcined. By this calcination, the acid salt is alkalized. This method, and the preparation of salt of tartar by calcining tartar, shew that vegetable alkali is produced by conversion of an acid to an alkali. How is this conversion effected?

The most common method of making pot-ash, is by burning large piles of wood, lixiviating the ashes by boiling in copper vessels, decanting the lixivium when clear, and boiling in other copper vessels till the liquor be evaporated and a reddish solid salt obtained, called *black pot-ash*, which by calcination in ovens with a heat not intense enough to fuse it, is dephlogisticated and rendered white. If any of it has been fused, it will have a greenish blue color.

Another method of preparing pot-ash, and which may be conveniently used in a large manufactory of it, is described by Kunkel. The ashes of wood are put into a large tub, near the bottom of which is inserted a cock; and to prevent the ashes from filling up the cock, the bottom is covered with straw and pieces of small wood. Water is to be poured

on the ashes, and is the next day to be let off through the cock into another vessel. The ashes may be again elixated with more water till all the salt be dissolved. The weaker leys are to be poured on fresh parcels of ashes till they can receive no more salt. The ley is then to be evaporated in an iron pan, and the brown salt is to be dephlogisticated by calcination in a furnace or oven with a heat not intense enough to fuse it.—Some persons soak straw in the ley obtained by lixiviating wood-ashes with water, and by drying and burning this straw they obtain a salt without the trouble of boiling the ley. The alkaline salt called *pearl-ash* has a whitish pearl color, and is almost entirely soluble in water. The Russian pot-ash is dark-colored, hard, not easily deliquescent, and contains (as Dr. Lewis says) more than half its weight of an earth unsoluble in water. Scheffer, in the Swedish Memoirs for the Year 1759, says, that from 100lb. of Russian pot-ash he obtained 92½ lb. of alkaline salt, and 7½ lb. of neutral salts. Dr. Home found that Russian pot-ash contained a considerable quantity of quicklime. From experiments made by Brandt (*Memoires Suedoises* 1749), and from the preference given to it by soap-boilers, it appears to be more caustic, and more powerfully to dissolve oils, than purer pot-ash rendered caustic by quicklime. Russian pot-ash is said to be prepared by burning wood with a close smothering heat; making a ley from the coarser part of the ashes, and moistening therewith the finer part into the consistence of a paste, stratifying this paste with some of the more inflammable kinds of wood, and setting the pile on fire. The neutral salts found in pot-ash are chiefly vitriolated tartar, sea-salt, with which latter salt pot-ash is frequently adulterated to increase its weight.

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it contains iron, it is in an insensible quantity, and it is naturally free from mixture of extraneous salts : therefore dyers and other manufacturers whose operations require a pure alkali, prefer these to any other alkaline ashes.

### FIXED ALKALI of TARTAR.

TARTAR, which is nothing but the concrete acid or essential salt of wine, being properly burnt, is almost entirely changed into an alkaline salt, very strong, and the purest of all ; and which therefore has been reasonably preferred by chemists to any other. It is called the *Alkaline Salt of Tartar*, or simply *Salt of Tartar*. Hence this name has become in some measure synonymous with that of alkali.

Salt of tartar is made by wrapping up in wet brown paper the tartar intended to be burnt, and placing these parcels so wrapped up in a furnace, by beds or strata, together with strata of charcoal, alternately ; and by setting fire to the whole, and continuing the fire till no more blackening smoke rises.

As tartar is almost entirely changed into alkaline salt, it preserves after incineration a certain consistence, and retains the form it had before burning ; which makes it easy to collect it properly. But too great heat must be prevented in burning tartar, otherwise the alkali would melt and flow to the bottom of the furnace, where it would mix with the impurities of the charcoal. To avoid this inconvenience a furnace entirely open may be employed, in which the charcoal may burn freely, but without any strong current of air to render the heat too intense. On the other side, as fire is generally more intense in great than in small operations, where proportionable quantities of combustible matters are used, when much tartar is to be burnt, it is proper to diminish the quantity of charcoal, to prevent too great heat, and the consequent fusion of the alkali.

When tartar is sufficiently burnt, a lixivium must be made from it till the water poured on it receives no more taste. It must then be filtered, evaporated, dried and calcined, according to the directions given to obtain the alkali of tartar in its greatest purity.

### FIXED ALKALI of NITRE.

THE basis of nitre being a fixed alkaline salt of the nature of the vegetable alkali, and the acid of this salt being capable of decomposition and total destruction by deflagration, we may obtain separately its alkali, called *alkalised or fixed nitre*, by burning or detonating it with combustible matters. As this combustion is very rapid, and as it is alkalised almost instantaneously by detonation, it has been also called *extemporaneous alkali*.

Those vegetable substances only which contain an acid yield an alkaline salt by incineration. From mustard and other vegetables which yield a volatile alkali and no acid by distillation, no fixed alkali can be obtained.

The ashes of firs, pines, and all trees

which contain much resin and essential oil, yield a small quantity only of fixed alkali by elixation. The cause of this seems to be, that the acid of these trees is very volatile, and together with a volatile inflammable matter forms the essential oils and resins. See RESINS.

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The matters most convenient and most frequently used for the deflagration of nitre are charcoal and tartar. The alkali made by deflagration of nitre with charcoal is called *NITRE fixed by CHARCOAL*. See this article for the method requisite.

Nitre and tartar burnt together produce a very strong alkali, which is a mixture of the alkali of nitre and of the alkali of tartar, both which are entirely of the same nature. They are confounded together by the name *NITRE fixed by TARTAR*. See that article, and *FLUX (WHITE)*.

These alkalis of nitre, when well prepared, are very pure, and fit for the nicest operations in chemistry.

All these several kinds of alkali, when perfectly purified, have entirely the same properties, and ought to be regarded only as one and the same alkali, which ought to be called *Fixed Vegetable Alkali*. The purification above-mentioned of this alkali is attended with considerable difficulties in practice. The chief of these difficulties is in the evaporation and drying of the alkaline lixiviums; and this relates to the vessels employed in these operations. Vessels made with the imperfect metals are unfit, because they are liable to the action of the alkaline salt. Silver vessels are the fittest of all for this purpose: but it is not very certain that this metal is incapable of being acted upon by alkali.

Glazed earthen vessels, such as common pottery-ware, cannot be employed, because they are not, and cannot be sufficiently baked. The alkaline lixivium passes through them as easily as through a filter. If vessels not metallic are to be used, they ought to be of glass or porcelaine, or made of pure clay, and baked in a violent fire, such as that kind of pottery called stone-ware. These vessels perfectly resist the action of alkalis, but they are very liable to be cracked by heat.

Well-prepared fixed alkali ought to be preserved, either dry or fluid, in crystal-glass bottles, with glass stoppers. When the fluid alkali is used, it must be gently decanted from the sediment deposited at the bottom of the bottles.

**XXXIII. ALKALI (MINERAL or FOSSIL), or ALKALI (MARINE).** This is a saline, alkaline, fixed substance, serving as a basis to the acid of common salt, and forming with it the native neutral salt which is dissolved in large quantities in the sea, and known by the names *Common Salt* and *Sea-Salt*. As this salt is a natural production, and belongs neither to the vegetable nor animal kingdoms, it has been ranged amongst minerals, and therefore called mineral alkali: notwithstanding that a considerable quantity of this salt may be obtained from the ashes of several vegetables. But its origin is always the same, and it is not to be considered a vegetable substance; for we shall see that mineral alkali obtained from vegetables, proceeds always from common salt contained in these vegetables. After we have mentioned the properties of this alkali, we shall describe the method of procuring it in its greatest purity.

Fixed mineral alkali has essentially and fundamentally all the properties of fixed vegetable alkali. It has the same taste and the same fixity. It dissolves all the same substances, and exhibits with them very similar phenomena. It melts and vitrifies all earths, and is altered by quicklime in the same manner. It combines

bines with all acids to the point of saturation, and with them forms neutral salts. It has the same action as fixed vegetable alkali on metallic substances, and forms soaps with oils and oily matters; therefore, in order to have a just idea of the alkaline properties of this saline substance, it is very necessary to read exactly and entirely what has been said under the articles ALKALI and ALKALI (FIXED VEGETABLE). But it also differs very considerably from fixed vegetable alkali by several properties peculiar to it; and it is upon these properties we are chiefly to insist in this article.

Fixed mineral alkali, which we here suppose to be in its greatest purity, differs from fixed vegetable alkali.

1. By its taste, which is a little less fiery and corrosive: but this difference is very slight.

2. When dried, it does not attract the moisture of the air sufficiently to form a liquid, as fixed vegetable alkali does.

3. If it be dissolved in water, when it is dry and calcined, it does not heat the water nearly so much.

4. When dissolved in water, and its solution evaporated and cooled, it coagulates into crystals, precisely as neutral salts do. In this it differs considerably from fixed vegetable alkali, which is absolutely deliquescent, and not crystallizable. (1)

The crystals of mineral alkali contain much water, and have but little adhesion to this water; for most of it is dissipated by exposure to open air. By this dissipation of water the crystals lose their form and transparency, which were owing, as of all neutral salts, to the water contained. *See* CRYSTALLIZATION.

Crystals of mineral alkali thus deprived of their water, fall into a white powder: therefore, to preserve them, they must be put into bottles as soon as they are drained.

The differences related betwixt the vegetable and mineral alkalis show that this latter possesses saline properties in a less eminent degree; which probably proceeds from the abundancy of its earthy principle.

5. Fixed mineral alkali dissolves by fusion, and vitrifies all earths like the vegetable alkali. But it has been observed, that it vitrifies earths better, and renders the glass more solid and durable. Probably this proceeds from the greater luxity of the mineral alkali, from its containing an earth less combined, and also from its want of the deliquescent quality.

6. With vitriolic acid, mineral alkali forms a neutral crystallizable salt called *Glauber's salt*, which differs from vitriolated tartar in the following circumstances.

1. Its crystals are of a different figure and larger size. 2. They contain more water. 3. They are more soluble in water. 4. Their adhesion to the water of their crystallization is less, insomuch that this salt by exposure to air loses its water, and consequently its form and transparency, and becomes a white powder, as the mineral alkali does also when exposed to air. *See* SALT of GLAUBER. As the same acid is in Glauber's salt and in vitriolated tartar, the differences above related must proceed from their alkaline bases: therefore all the properties which distinguish Glauber's salt from vitriolated tartar are to be considered as the dif-

(1) We have observed in a note upon the former article, that fixed vegetable alkali is crystallizable by exposure to fixable air.



ferences betwixt the vegetable and mineral alkalis. The same observation may be applied to all combinations of mineral alkali with the other acids, of which we are now going to speak.

7. With nitrous acid, mineral alkali forms a particular kind of nitre, susceptible of detonation and of crystallization; but it differs from ordinary nitre, or that which has for its base fixed vegetable alkali, in the figure of its crystals, which, instead of being like long needles, are solids, each of which has six rhomboidal faces; that is to say, two angles of each face are acute, and the other two obtuse. This figure, which is somewhat similar to that of a cube, has occasioned this salt to be called *cubic* or *quadrangular nitre*. This figure is caused by the mineral alkali. See NITRE (QUADRANGULAR).

8. With marine acid, mineral alkali forms common salt, the crystals of which are perfect cubes. This salt differs from the neutral salt formed by the combination of the same acid with vegetable alkali chiefly by its taste, which is infinitely more agreeable. See SALT (COMMON).

9. Mineral alkali forms with the acid of vinegar a neutral salt entirely different from the *terra foliata tartari*, which is deliquescent and not crystallizable, while the former crystallizes well, and does not attract the moisture of the air. This salt has no particular name. See SALT (NEUTRAL) Composed of the ACID of VINEGAR and of MINERAL ALKALI.

10. With the concrete tartareous acid, mineral alkali forms a neutral crystallizable salt, differing from that made with the same acid and vegetable alkali, or *vegetable salt*, by the figure of its crystals, which are also much larger and finer. See SALT VOLATILE.

11. Mineral alkali very well dissolves oils and oily matters, and with them forms saponaceous compounds, as the vegetable alkali does. But soaps made with this latter alkali remain soft, and do not acquire such consistency and hardness as those made with mineral alkali. This difference is certainly caused by the property which mineral alkali has of crystallizing. See SOAP. (1)

It is probable, that if we were to examine attentively the combinations of marine alkali with sulphur and metallic substances, sensible differences might be discovered from similar combinations made with vegetable alkali. The discovery of these differences could not fail to throw new light upon the nature of this alkali. But I do not believe that sufficient experiments have been made on this subject. (m)

Several celebrated chemists have, however, made considerable researches into the nature of marine alkali. The person who has done most in this way is M. Duhamel de Monceau, a member of the Academy of Sciences. He has published

(1) The difference mentioned in the text does certainly not proceed from the crystallizing quality of mineral alkali; for this salt probably proceeds from that property of mineral alkali by which it has a weaker power of combination with water than vegetable alkali.

and renders it caustic, and incapable of forming crystals. See AIR (FIXABLE). The greater hardness of soaps made with mineral alkali than of those made with vegetable alkali, vegetable alkalies; namely, that platinum may be precipitated from its solution in aqua regia by the latter, but not by the former.

in several memoirs, a detail of many experiments made to decompose common salt, that he might obtain the alkaline basis single and pure, for the purpose of examining its properties. Common salt not being capable of decomposition merely by the action of fire, and without the application of another substance, it was necessary to find some substance which could carry off the marine acid, without combining itself with the alkaline basis. As phlogiston produces this effect very well on those neutral salts which are composed of a fixed alkali and vitriolic or nitrous acids, it was natural to try the separation of the marine acid by the same intermediate substance. This M. Duhamel did, but without success; altho' in his experiment he employed every resource of the most enlightened chemistry. The same thing happened to Mr. Margraaf, who tried without success to combine marine acid with phlogiston, in order to produce phosphorus. It appears, then, that art does not yet furnish any method of decomposing common salt by phlogiston.

It is nevertheless probable that this decomposition is not impossible, and that it even takes place every day in the combustion of maritime plants of the *kali* kind, all of which contain sea-salt, and when burnt, furnish a considerable quantity of crystallizable alkali, which being combined with the vitriolic and nitrous acids forms Glauber's salt and cubic nitre, entirely similar to those formed from the decomposition of common salt by these two acids. It is very probable that this crystallizable alkali obtained from the ashes of maritime plants, proceeds from a portion of sea-salt contained naturally in these plants, a part of which is decomposed by the burning; for it is certain that no trace of a disengaged alkali can be observed in these plants previously to their incineration.

However that be, it is certain that this crystallizable alkali obtained from the ashes of maritime plants, is entirely of the same nature as the natural alkaline basis of sea-salt. This is a truth which no chemist questions. But disputes have arisen concerning the saline alkaline nature of this substance.

The inquiries of M. Duhamel had proved to him, that it had the principal marks of a saline alkali; he concluded that it really was such. On the contrary, the celebrated Mr. Pott, who has also made many experiments on this matter, has always maintained that it was only a pure earth, without the properties of an alkaline salt. This diversity of sentiments has occasioned a literary discussion betwixt these two learned gentlemen, of that kind which always turns out to the advantage of science; as it has occasioned a great number of beautiful experiments, which greatly illustrate this matter.

The strongest proof brought by Mr. Pott in support of his opinion may be found in the éclaircissements given to the sequel of the French translation of his *Lithopœgnosia*. Mr. Pott says, "that by a fixed or volatile alkali an insipid and perfectly insoluble earth may be precipitated from the mother water of sea-salt. This earth united to the vitriolic acid forms a Glauber's salt perfectly similar to that prepared from sea-salt. This Glauber's salt produces with charcoal a saline alkaline body, which is not precipitable by fixed vegetable alkali; which also happens precisely to Glauber's salt prepared with sea-salt. This alkaline salt is not produced by the vitriolic acid, nor by the charcoal, but principally from this saline earth, which for that reason may be called an alkaline earth, nearly approaching a saline state, and which is capable of taking from acids a proper

"proper portion of their most subtle parts, by combination with which it becomes a genuine alkali."

As to what remains, it appears that, after the properties of fixed alkaline salts and of the basis of sea-salt have been established, it is easy to decide the question. Nothing can be said more sensibly on this subject than the following quotation from the learned and judicious translator of Mr. Pott's *Lithoæognosia*. "This question is now reduced to a dispute about words, since Mr. Duhamel agrees with Mr. Pott that the basis of sea-salt differs from the fixed alkali of nitre and others similar; and that Mr. Pott agrees with Mr. Duhamel, that it differs from common absorbent earths. But hitherto it seems that Mr. Duhamel's expression is more just and conformable to the definition of saline substances."

From all this we ought to conclude, that the basis of sea-salt is neither a pure earth, nor an alkali similar to that obtained from vegetables, but a saline alkaline substance of a peculiar nature; and if conjectures may be allowed on the nature of this alkali, I should be inclined to believe, that it differs from the vegetable alkali, either because a larger quantity of earth enters into its composition, or because its earthy principle is united to it more intimately.

Further, it appears that the basis of common salt is truly of a saline nature, from its successful and even advantageous application to all the same purposes in the arts as fixed vegetable alkali, as has been said above.

The only practical method of procuring this alkali in great quantities is by the incineration of maritime plants. These ashes contain much mineral alkali, when the plants happen to grow in a favorable soil and climate, and the mineral alkali is found to be more or less pure, according to the nature of the plants and of the soil. These ashes are generally known in commerce by the name *Soda*. This soda is employed in arts without purification; hence there is observed a great difference betwixt different sodas, some of which are much better than others. (n)

As the chemical affinities and the medicinal virtues of the mineral and of the vegetable alkalis are the same, we proceed to mention what is most material on these subjects.

The *affinities of fixed alkali*, according to Mr. Geoffroy's table, are in the following order: vitriolic acid, nitrous acid, marine acid, vinegar, sulphur.

Mr. Gellert's table is more extensive, and is as follows: Phlogiston, vitriolic acid, nitrous acid, marine acid, vegetable acid, zinc, iron, copper, lead, tin, regulus of antimony, regulus of cobalt, arsenic and bismuth. Gold and silver are marked in this table as insoluble by fixed alkali.

As fixed alkalis are the greatest absorbents of acids, they are proper for all those maladies described by Boerhaave as proceeding from a spontaneous acid.

(n) Mineral alkali is found lying upon the ground in the island of Teneriff, and in many other countries. The Spanish ashes called *barilla*, or *soda*, are produced by burning kelp, varech, or *Sucus maritimus*, *alga marina*, and other maritime plants, previously dried, in pits dug in the ground. The fire employed is so violent as to fuse the ashes into one large and hard bluish mass. From these plants Henschel obtained, by boiling in water, evaporating and crystallizing, a considerable quantity of marine salt. Stahl,

Gellert, and other authors, prefer this salt to vegetable alkali, for the formation of glass, durable, and not attackable by acids. But Kunkel observes, that the impurities mixed with common soda, or *barilla*, give a bluish color to glass, and render it liable to crack, when cooled. Stahl observes, that the same effect is produced by common pot-ash. The mineral alkali, as has been observed in the text, makes a finer, harder soap than vegetable alkali. It is also said to be more effectual in the reduction of metallic calxes.

They

They are even preferable to absorbent earths, (although these latter are more frequently used) in cases where, notwithstanding signs of acidity, a putrescent disposition is apprehended; which is not at all impossible, because they are, like all saline matters, antiseptic, according to the observations of Dr. Pringle. But if the putridity was advanced to alkalescency, which is very rare, they would be very hurtful, because they would encrease this alkaline acrimony.

It must not be supposed that fixed alkalis taken internally enter the blood-vessels with their alkaline qualities. If that happened, they would be true poisons, as acids are; since they quickly kill animals into whose veins they are injected.

The human constitution, which cannot suffer the presence of any sensible and disengaged acids or alkalis, at least to a certain degree, in our fluids, acts upon alkalis taken internally by combining them in digestion with the acids of aliments, or with their oily parts, forming soaps, in which conditions only they can arrive at the blood.

Pure alkalis ought never to be prescribed but in small doses, as from half a grain to two grains, when they are incorporated with solid medicines and in small bulk; but they may be given from one to six grains, if they be diluted, on account of their causticity, in a pint of some watery vehicle. These saline substances are dissolving, aperitive, and lithontriptic. They are not much employed for these qualities; but are principally used to correct resinous purgatives, which they do very well, by giving to these medicines a saponaceous quality. Externally applied, these alkalis are resolvent, discutient, and caustic. (o)

XXXIV. ALKALI (VOLATILE). Volatile alkali is a saline substance procured by decomposition, from all animal, and from some vegetable substances, and by putrefaction from all these matters. (p)

This saline substance is called *alkali*, because in fact it has all the general properties of saline alkalis, as the sharp, caustic and burning taste; the property of

(o) Dr. Smith, in a treatise *de motu musculari*, mentions an extraordinary fact which he affirms to have ascertained by repeated experiments, namely, that of the many substances which he mentions, acid, alkaline, and corrosive, mineral alkali and compounds formed of it, were alone capable of stimulating or irritating the muscles of frogs, by immediate application to them, which were exposed for the sake of making these experiments.

(p) The plants from which volatile alkali is obtainable by distillation are chiefly of the cruciform kind. This salt is obtained by distilling all kinds of clays, (as Brandt says) many calcareous earths, chiefly that kind called *Lapis stillus*, and some mineral waters. Sal ammoniac, which contains volatile alkali, is sublimed in volcanos. Sal ammoniac may be produced from (o) of burning vegetable or animal substances, and even of mineral coal. Authors mention various methods by which volatile alkali may be pro-

duced. As a knowledge of these may assist us to form a theory concerning this saline substance, we shall relate some of them. Volatile alkali may be produced by heat, 1. From a mixture of quicklime with vitriol, or with alum, or with tartar. *Pott.* 2. From a mixture of any essential oil with vitriolic acid and fixed alkali. *Id.* 3. From nitre detonating with charcoal. *Id.* 4. From a combination of marine acid with quicklime. *Id.* 5. From magnesia alba by distillation. *Dr. Black.* 6. From tartar. *Id.* 7. From deliquated salt of tartar poured on white salt of vinegar. *German Bphemerides, Pott, Ludowick, and Hoffmann.* 8. From sea-salt combined with putrefying substances. *Pott.* 9. From sea-salt distilled with charcoal. *Id.* 10. From sea-salt distilled with quicklime. *Id.* 11. From salt of Sylvius distilled with fixed alkali. *Beck and Peurman.* 12. From sea-salt distilled with clay. *Brandt.* 13. From rust of iron distilled. *Bourdelin.*

tinging violets with a green color; of combining with acids to the point of saturation, and forming with them different neutral salts, most of which are crystallizable; of separating all earthy and metallic matters from their union with acids; lastly, of dissolving by the humid way, almost all substances soluble by other alkalis.

This alkali is called *volatile*, because in fact it is very much so. Its volatility is owing to a portion of attenuated, very subtle, and very volatile oil, which enters into its composition as one of its principles, as is proved by its distinguishing properties.

Volatile alkali differs according to the substances whence it is procured, and according to the manner of obtaining it. These differences proceed from some principles superabundant and extraneous; particularly, several oils from which it is not at first exactly depurated. But all volatile alkalis, however obtained, and from whatever substances, may be so purified by the method which shall be soon described, that no difference remains amongst them; and hence we ought to conclude of this substance, as well as we did of the various kinds of fixed alkali, that it is single, identical, and always similar to itself, when sufficiently purified.

Pure volatile alkali differs from fixed alkali, first, by its greater volatility, which is so great that it may be entirely sublimed or dissipated by a heat much less than the heat of boiling water; by its smell, which is only an effect of its volatility: the smell of this salt is strong, very penetrating, and so pungent, that it cannot be endured above an instant, without suffocation or fainting; its vapor, excites a cough, and brings tears into the eyes. It is this salt which occasions the pungent smell observed in necessary-houses at changes of weather.

This alkali differs also from the fixed by its less force; hence fixed alkalis are capable of decomposing all those salts whose bases are volatile alkali, of separating it from these salts, and of setting it at liberty.

Volatile alkali unites perfectly with water, to which it has even a strong affinity, and with it retains fluidity: it is then called volatile alkaline spirit. When it contains no superabundant water, it is in a concrete form, and is crystallized, in which it differs from fixed vegetable alkali. (q)

All acids unite and effervesce with volatile alkali to the point of saturation, forming neutral salts generally called *ammoniacal salts*.

Ammoniacal salts have an infinitely stronger and more pungent taste than salts whose bases are fixed alkali, because volatile alkali unites with acids less intimately. These neutral salts are semi-volatile; that is, they may be sublimed by a sufficiently strong heat; and this property they owe to the volatility of their alkaline basis.

The ammoniacal salt which volatile alkali forms with vitriolic acid is crystallizable, and is called *vitriolic ammoniacal salt*, or *secret ammoniacal salt of Glauber*, from the name of the chemist who discovered it. See these words.

The kind of nitre formed by volatile alkali and nitrous acid is also crystallizable; and has the peculiar property of detonating alone, when heated sufficiently, without addition of any matter containing phlogiston, as is necessary for

(r) Volatile alkali, by combination with fixable air, is crystallizable; uncombined, it cannot be obtained in a solid state.

the detonation of ordinary nitre. This phenomenon proves the existence of the inflammable principle in volatile alkali. This nitre, whose basis is volatile alkali, is called *ammoniacal nitre*, or *nitrous ammoniacal salt*. See *these words*.

With marine acid, volatile alkali forms also a neutral crystallizable salt, called *Sel Ammoniac*. This is the most used, and first known of the ammoniacal salts, and from which the name has been derived to the others. See *SAL AMMONIAC*.

Volatile alkali may be combined with sulphur, with which it forms a kind of volatile liver of sulphur, the preparation of which is given by Hoffman. See *LIVER of SULPHUR*.

Most metallic matters are attacked, and more or less dissolved by volatile alkali; but copper is of all metals the most easily and copiously dissolved by it. To dissolve this metal nothing more is requisite than to digest its filings in liquid volatile alkali. The solution acquires a beautiful blue color.

This solution exhibits a curious and interesting phenomenon, which is, that if the bottle containing it be well corked, the blue color grows fainter, and at length entirely disappears, so that the liquor becomes colorless like water. But if the same bottle be then uncorked, the upper part of the solution from its contact with the external air resumes its color, and this color is gradually communicated to the rest of the liquor. Thus may this blue color be made to appear and disappear alternately, as often as is required, by corking and uncorking the bottle.

Other metallic matters are not nearly so easily attacked by volatile alkali as copper is. These solutions have even not been much examined.

When metals are previously dissolved and divided by acids, they are then infinitely more susceptible of solution by volatile alkali. For this purpose it is sufficient to pour into some strong alkaline spirit some drops of metallic solution. At first a precipitate is formed, which soon disappears upon agitating the liquor, and is redissolved by the volatile alkali. That this experiment should succeed, it is necessary that the metallic solution should have a considerable excess of acid; that is, that the acid should not be nearly saturated with the metal. By this method, copper and mercury are dissolved in greater quantity than other metals.

In whatever manner the copper be dissolved by this salt, it always communicates a blue color, very beautiful and deep. This property renders the alkaline spirit a proof liquor to discover copper, and render it sensible when it could not, from the smallness of its quantity, be perceptible by other methods. Thus a little volatile alkali may be poured into any mineral water, containing too small a quantity of copper to be otherwise perceptible. The blue color which this water assumes discovers the presence of copper.

Volatile alkali, added gradually to a metallic solution, seizes the acid of the solution, and precipitates the metal. The most singular metallic precipitate made by volatile alkali is that of gold previously dissolved in aqua regia. This precipitate is of a yellow color, and is one fourth part heavier than the gold employed. (r) When heated to a certain degree, it detonates and fulminates with a most terrible explosion. It is called *fulminating gold*. See *GOLD (FULMINATING)*.

(r) Dr. Black, in his Essay upon Magnesia, attributes the increase of weight which metallic precipitates gain, to adhering fixable air, which they receive from the precipi-

tating alkalis. To this adhering air he also attributes the fulminating property of the precipitate called *Fulminating Gold*.

Mercury dissolved in spirit of nitre. and precipitated by volatile alkali, is of a slate color. This color proceeds from the inflammable matter of the volatile alkali. The other metallic precipitates made by volatile alkali have nothing singular: none of them fulminates like the precipitate of gold; even that of platina does not, tho' this metal possesses so many of the properties of gold. (.)

Volatile alkali, as well as fixed, acts upon oils, and forms with them different saponaceous compounds; hence this salt may be employed to scour and clean from grease; and lixiviums made of quicklime and urine which contain much volatile alkali, are used in some arts. This alkali is nevertheless less easily united with oils than fixed alkali is, and particular management is necessary to bring it to a saponaceous state. See SPIRIT (VOLATILE AROMATIC OILY); and EAU DE LUCE. These are the principal saponaceous compounds made with volatile alkali.

Volatile alkali, when first separated from animal and vegetable matters, is, as we before observed, very impure. It is particularly depraved by much empyreumatic oil, which is united with it into a slate perfectly saponaceous, and which it renders soluble in water. It may be separated from this superfluous oil by distilling it with a very gentle fire, either alone, or mixing with matters capable of absorbing and retaining the oil, as fixed alkalis and absorbent earths are. But the most efficacious method of purifying it is, to reduce it to sal ammoniac, and then to decompose this salt, by any of the proper mediums for the disengagement of the volatile alkali. By this method it is obtained in its greatest purity; because, in its combination with the acid, it perfectly separates itself from all extraneous matter. See SAL AMMONIAC, for the purification of volatile alkali, and for several of its essential properties. (t)

The affinities of volatile alkali, according to Mr. Geoffroy's table, are, vitriolic acid, nitrous acid, and marine acid. According to Mr. Gellert's table they are, phlogiston; viurilic, nitrous, and marine acids; vinegar; zinc; iron; copper; bismuth; mercury; silver; and gold.

(.) From Mr. Maignaaf's Experiments, published in the Berlin Memoirs for the year 1745, we find that gold, silver, bismuth, zinc, and copper, dissolved in their proper acid solvents, may be first precipitated from these, and afterwards redissolved by volatile alkali; that these metals precipitated by fixed alkalis may be again dissolved by volatile alkali; and that mercury, lead, and tin, were not dissolved by volatile alkali applied in the same manner. Brandt says, that volatile alkali occasions a coagulation of a solution of iron in nitrous acid, which is soon redissolved; and that the same alkali precipitates iron from vitriolic acid. He also says, that regulus of cobalt cannot be precipitated from nitrous acid, nor arsenic from aqua regia, by volatile alkali. Volatile alkali has no effect upon any metal not previously dissolved by acids, excepting copper, iron, and lead; the first of which it dissolves perfectly, a very small quantity of the second, and the third

is very slowly changed by it into a kind of mucilage. See POTT *jur la Dissolution des Corps*.

(t) To the properties above-mentioned of volatile alkali, we may add, 1. That pure or caustic volatile alkali, that is, uncombined with fixable air, or the spirit of sal ammoniac obtained by quicklime, is soluble in spirit of wine, and that mild volatile alkali is not soluble in that spirit; hence if a strong solution of mild volatile alkaline salt be added to spirit of wine, the water of the solution will combine with the spirit, and the salt will be precipitated, forming what is called *Offa Helmontii*. 2. Mild volatile alkaline salt requires four times its quantity of water to dissolve it: caustic volatile alkali, as we have already observed, is always combined with water. 3. Volatile alkali desagrates with nitre, which proves that it contains an inflammable matter.

Volatile alkali is employed in medicine as a powerful stimulant and exciter, when applied so that the person shall inhale the vapors of it. Thus it is applied in faintings, synopes, apoplexies, and in all lethargic diseases, in which the nervous parts are benumbed and unbraced. In these cases it is usually applied in bottles, either in a concrete form called *English Salt*, or in a fluid form, and reduced to a semi-saponaceous state by mixture with oil of amber, when it is called *Eau de Luce*. See SALT (ENGLISH); and EAU DE LUCE.

It may also be taken internally in these cases, particularly in apoplexies and lethargic diseases, but in small doses, as from two or three grains to six, and added to stimulant mixtures. Taken in this manner, it sometimes is a powerful sudorific.

M. Bernard de Jussieu has discovered that this saline substance is a specific against the bite of vipers; having cured as it were miraculously, by means of eau de luce, a student of medicine, to whom this accident happened, while he was botanizing.

XXXV. ALKALISATION. This name is applied to operations by which alkaline properties are communicated to bodies; or to those by which alkali is extracted from bodies which contain it, or in which it may be formed. For example, *spirit of wine* is said to be *alkalised* when it has been digested upon alkali, a part of which it dissolves, and thence acquires alkaline properties. On the other hand, when a neutral salt is decomposed in order to obtain its alkaline basis, this salt is said to be alkalised. Thus nitre, deprived of its acid by detonation with inflammable matters, as charcoal, tartar, metals, so that nothing remains but its alkali, is called *Nitre alkalised by Charcoal*, or by *Tartar*, &c.

Vegetable substances, when reduced to ashes, may also be said to be alkalised; because these ashes contain fixed alkali. See the detail of particular alkalisations, under the articles of the different ALKALIS.

XXXVI. ALKOHOL. This name has been given to any impalpable powder. See PORPHYRISATION.

It has also been given to highly rectified spirit of wine. See SPIRIT of WINE.

XXXVII. ALLAY. This word is employed in chemistry to signify the union of different metallic matters.

As an infinity of different combinations may be made according to the nature, the number, and the proportions of the metallic matters capable of being allayed, we shall not here enter into the detail of the particular allays, all which are not yet nearly known. Those which are used, as *Bronze*, *Stambac*, *Brass*, *White Copper*, &c. may be found under their particular names; and what is known concerning other allays may be partly found under the names of the different metals, and ferrometals, and partly in this article.

Metallic substances cannot unite directly with earthy matters, not even with their own earths, when deprived of their inflammable principle, and consequently of their metallic properties. But in general it may be said, that all metals may be allayed with each other, although more or less easily, and although some of them have not yet been made to unite.

As metals are bodies naturally solid, the first condition for their union is, that they be fused. They then unite, like all bodies which reciprocally dissolve each other, and from these combinations new compounds result, which have the mixed properties of the component substances. See COMPOSITION (CHEMICAL).



In these metallic alloys, as in almost all other metallic combinations, phenomena appear which depart from the general rules of combinations. Thus it is observed, that some of the properties of metals forming an alloy are altered, increased, or diminished by their union. The ductility, for instance, of a metallic composition is generally less than the ductility of the component metals alone and pure. The density or specific gravity of metals and semimetals is also changed by alloying them with each other. Sometimes the specific gravity of the compound is intermediate betwixt the specific gravity of the component metals, sometimes it is less, and frequently greater: this depends upon the nature of the metals. The same observation may also be applied to the colors resulting from the alloys of metals.

Metallic alloys are either *natural* or *artificial*. The first are those made by nature, such as most minerals, containing several metals alloyed with each other. Native gold is always more or less alloyed with silver; and native silver with gold.

*Artificial alloys* are those made expressly for different uses, or for the sake of examining their properties.

Although the alloys of different metallic matters are of great importance to the theory and to the practice of chemistry, yet all the researches which the subject deserves, and is capable of, have not been made. Mr. Gellert is one of those who have done most in this way. In his *Metallurgic Chemistry* there are a great number of experiments, which we shall relate here summarily. The experiments made for the alloying of semimetals with metals are his own, and were undertaken to determine the specific gravities of these alloys. He relates the others before known, from chemical writings, and particularly from a Dissertation of Mr. Kraaft expressly on this subject. We shall refer the alloys of mercury with other metals, called *Amalgams*, to the word *AMALGAM*.

Gold may be easily united with silver, and in all proportions. Mr. Gellert says, that this alloy is nearly of an intermediate gravity betwixt the gravities of the two metals, and but a very little augmented. This alloy is of no use in the arts: on the contrary, as pure metals are always more ductile than alloys, in the arts where ductility is requisite, as in wire-drawing, gold-beating, the purest metals are chosen. (u.)

Silver may be easily alloyed with copper, and in all proportions: copper also unites in the same manner with gold. Gellert observes that the alloy of silver

(u.) The component metals of which metallic alloys are formed may be either chemically combined, that is, mutually dissolved by each other; or mechanically mixed, that is, diffused through each other by the action of fire; or they may be partly combined, and partly diffused, if the proportion of their quantities to each other be different from that which is necessary for their combination. For most, if not all, metals can be only combined with each other in certain proportions, as is very observable in those, the fusion of which requires very different degrees of heat. But those which may be kept fused in nearly the same degrees of heat may be mixed together in almost any proportion, and will be nearly uniformly diffused throughout the metallic mass when hastily cooled. As metallic alloys have not been before considered in this manner, no experiments have been made to determine the proportions with which they can combine; nor can we easily establish rules by which this kind of combination can be ascertained. Those, however, which appear to me most probable, for distinguishing this combination, are, 1.

When.

and copper is of a greater than the intermediate gravity; but that the alloy of gold and copper is of a gravity less than intermediate. Copper renders gold and silver harder and more sonorous, without much diminution of their ductility. It has even the remarkable property of rendering these two metals less susceptible of losing their ductility by the vapor of charcoal, which they are very liable to do; copper also heightens the color of gold. These properties of copper relatively to gold and silver render its alloy with these metals of great use to gold and silver-smiths; because it makes them firmer, and fitter for working and chasing; and also for making money, for the same reasons; and for the payment of the Prince's duties, and for compensation of the expences of coining. The quantity of copper alloyed with gold and silver for these different uses varies according to the different countries, but in each country it is fixed, and always the same.

Iron alloys well with silver, and still better with gold. Gellert observes, that the gravity of an alloy of gold and iron is less than the intermediate. The affinity of these two metals is very great; for gold facilitates its fusion, which indi-

When an alloy possesses properties which neither of its component metals had. 2. When the properties, as the specific gravity, color, hardness, &c. of the alloy, are not in an intermediate degree betwixt the same properties of the component metals, according to the proportion of these metals to each other. 3. When the component parts of an alloy are not separable from each other by eliquation; that is, by applying a heat capable of fusing one of them only; nor by keeping the whole mass in fusion, with a heat not more intense than is necessary for that purpose, but insufficient to occasion an ebullition, and by cooling the melted mass very slowly. When therefore, according to these rules, a metallic alloy has no properties but those which its component metals had; when its density, color, hardness, elasticity, fusibility, and other properties, are precisely in an intermediate degree betwixt those of its component metals; and lastly, when its component metals may be separated from each other by eliquation, or by giving them such a fluidity and rest as that they may separate according to their respective densities; we may then, with probability, pronounce that this alloy is composed of parts not chemically combined: and when to an alloy, which by these rules is composed of metals chemically combined, a quantity of one of the same kinds of metal of which the alloy is composed, be added, and, upon examination, the new alloy be found to possess no properties but such as are intermediate betwixt the first alloy and the added metal, and to be separable by eliquation, or by their different densities, we may then consider this new alloy as a mass consisting of metals partly combined, and partly diffused. That the alloy mentioned in that part of the text to which this note refers, namely, that of gold with silver, does not consist of parts chemically combined, or else that but a very small proportion of each of these metals can be combined with the other, appears probable from the following reasons. 1. The density of the alloy is very nearly intermediate between the densities of the component parts. 2. The silver and gold are not uniformly and equally distributed through the whole mass. This inequality is proved by an experiment of Mr. Hellot. He melted a mass of 20 pounds, containing 55 parts of silver and one part of gold, and poured it into three separate masses, each of which was found by essay to contain a different proportion of gold from the two others. 3. Gold and silver kept in gentle fusion are separable from each other, merely by their different densities. Mr. Homberg kept equal parts of gold and silver in gentle fusion a quarter of an hour, and found, upon breaking the crucible, two masses, of which the upper was pure silver, and the lower the whole gold alloyed with 1/5th part of silver. He repeated the experiment with nearly the same event; and twice he obtained the two metals perfectly separated from each other. See a note to the article AFFINITY.

cates

ates a strong disposition to unite. Gellert observes upon this occasion, that therefore gold is fitter than copper for soldering fine works of iron and steel. (w) Iron unites difficultly with copper, and in small proportion. It renders copper paler. The portion of iron which does not unite with copper forms a separate regulus, which, however, strongly adheres to the surface of the regulus of copper. The degrees of affinity of iron with other metals, according to Gellert's table, but reversing the order in which he has placed them, (that is to say, beginning by those with which it has the strongest affinity, which seems to be the most natural order) are, gold, silver, and copper.

Tin, according to the same author, unites with all metals, and renders them brittle; iron and lead it alters least in this respect. (x) But gold and silver are so affected by tin, that its vapor alone is capable of destroying the ductility of a large quantity of these metals, as is well known to artificers.

The alloy of tin with gold and silver is then of no use; on the contrary, it is carefully avoided; but with copper tin forms an useful compound, known by the name of *Brenze*. The specific gravity of alloys of silver and of copper with tin is greater, and that of gold with tin is less than the intermediate. The affinities of tin with other metals, according to Gellert's table, (only reversing his order, which we shall always do) are iron, copper, silver, gold.

Lead unites with all metals, excepting iron, with which no method has been found to unite it. Gellert observes, that this property of iron with regard to lead renders it fit to separate this latter metal from others, provided that the metal from which it is to be separated has not a greater disposition to unite with lead, than the iron has to unite with it. This is certain, that lead may serve as an intermedium by which iron may be separated from other metals: for instance, from silver. For if a sufficient quantity of lead be melted with silver alloyed with iron, it will easily seize upon the silver, and separate the iron from it, which will then swim upon the surface of the two melted metals.

The alloys of gold and of silver with lead have a greater specific gravity, and the alloys of copper and of tin with lead have a less specific gravity, than the intermediate.

The alloy of lead with other metals is used for the essays of ores, for refining, and for liquation. See LIQUATION.

Lead and tin are alloyed together to form a solder for pipes and other works of lead.

The affinities of lead with other metals, according to Mr. Gellert's table, are, silver, gold, tin, copper.

Zinc may be alloyed with all metallic matters, excepting bismuth, with which it cannot unite, according to Mr. Gellert. This semimetal, when united with metallic substances, gives fusibility to those which are less fusible than itself. The density of alloys of gold, of silver, of copper, and of lead with zinc is greater; and that of alloys of the same semimetal with tin, iron, and regulus of antimony, is less than intermediate.

(w) A very small quantity of iron renders gold hard, brittle, and pale. So hard are some mixtures of iron and gold, that they are said to have been formed into razors. Three or four parts of iron and one part of

gold compose an alloy nearly as white as silver.

(x) Equal parts of tin and iron form a white but brittle mass.

The allays of zinc with most metallic matters are not used in the arts, but that with copper is very much. This allay forms *Brass*, *Tombacs*, *Prince's Metal*, *Pincbeck*, &c.

The affinities of zinc with other metallic matters are, according to Gellert's table, copper, iron, silver, gold, tin, lead *partly*; that is, it does not unite with lead in all proportions.

Bismuth unites with all metals, and with most semimetals. It has so great action upon other metallic substances, that it sensibly facilitates their fusion. (y) Bismuth renders all the metals with which it is united brittle. It does not unite with zinc; nor, according to Mr Gellert, with arsenic. When melted along with zinc, it remains at the bottom of the crucible, as being the heavier of the two; and when they are cooled, they are found forming two distinct reguli adhering strongly to each other. Gold, silver, lead, and regulus of antimony form with bismuth allays of greater, and iron forms an allay of less, than intermediate density, and copper forms with it an allay of intermediate density.

The allays of bismuth are not in use, excepting some particular metallic compositions for mirrors.

The affinities of bismuth with other metals are, according to Mr. Gellert's table, in the following order: iron, copper, tin, lead, silver, gold.

"Cobalt" \*, says Mr. Gellert, "may be allayed with\*all metals and semimetals; but it acts little upon lead and silver. When equal parts of lead and cobalt are melted together, these two substances are found only adhering to each other, the lead being, in consequence of its greater specific gravity, at the bottom of the crucible, and the cobalt above it; so that it seems probable that they are not at all combined. But if the same cobalt be melted, after it has been thus treated, with iron, which seems to be the most readily united with it of all the metals, a small regulus of lead is found at the bottom of the crucible, because iron and lead do not unite. At first, we might be apt to believe that silver and cobalt do not unite together. In fact, if two parts of cobalt, and one part of silver be melted together, the silver is found at bottom and the cobalt above, only adhering to each other: But the silver is become more brittle, of a greyish color; and the cobalt is become whiter than before. If this silver be cupelled, the part of the cobalt united with it will attach itself to the cupell in form of a circle, and the silver will be found

(y) Bismuth greatly encreases the fusibility of some metals, as appears from the following table of Dr. Lewis, in which the degrees of heat are marked in numbers according to Fahrenheit's scale.

600. Mercury boils.

540. Lead melts.

460. Bismuth melts.

410. Tin melts.

390. Tin 8 parts, bismuth 1 part, melt.

330. Tin 2 parts, bismuth 1 part, melt.

Tin 3 parts, lead 2 parts, melt.

280. Tin and bismuth, equal parts, melt.

212. Water boils.

An allay composed of two parts of lead, three parts of tin, and five parts of bismuth, may be melted with considerably less heat than the most fusible of those mentioned in the above table.

\* Note. By *Cobalt* Mr. Gellert certainly means what we call *Regulus of Cobalt*; for *Cobalt* properly called is a mineral composed of other substances besides the regulus of cobalt, as sulphur, arsenic, bismuth, silver, and unmetallic earths. See *COBALT*.

“to have lost an eighth part of its weight, which will be found upon essaying the cobalt, and examining how much silver it contains.” *Metallurgic Chemistry*, Tom. I.

These experiments of Mr. Gellert's prove, that regulus of cobalt cannot be united to lead and to silver in all proportions, but only in small quantity. The same may be said of bismuth, with which, says Mr. Gellert, cobalt is very easily united: for Mr. Beaumé, who has made many experiments on the regulus of cobalt, has observed, that when this regulus is melted with bismuth, these two metals are found separate, the bismuth being at the bottom of the crucible and the cobalt above it.

The allays of the regulus of cobalt are but little known, and not used in the arts.

In Mr. Gellert's table the affinities of regulus of cobalt with metallic matters are in the following order: copper, iron, tin, zinc, regulus of antimony, bismuth and lead, silver, and arsenic, partly.

Regulus of antimony may be allayed with almost all metallic substances. Mr. Gellert says, that the density of allays of this regulus with iron, tin, or zinc, is less than intermediate, and that the density of allays of this regulus with silver, copper, lead, and bismuth, is greater than intermediate. He observes also, that the magnetic property of iron is much more diminished by an allay of that metal with regulus of antimony than with any other metallic substance.

Allays of regulus of antimony are little used in the arts. It is used for some compositions for speculums. An allay of this semimetal with iron, tin, and copper, is made for the preparation of a medicine called *Lilly of Paracelsus*, or *Tincture of metals*. See LILLY of PARACELSUS.

The affinities of the regulus of antimony with metallic substances are placed by Mr. Gellert in the following order: zinc, copper, tin, lead, silver, gold. Bismuth is so placed in the table as to denote its incapacity of uniting with the regulus of antimony.

Arsenic, or its regulus, unites with most metallic matters. Mr. Gellert says, that it whitens iron; but the allay resulting from thence is very brittle. Copper is also rendered very white by mixture with arsenic. This is the *white tamber* which resembles silver. Mr. Gellert affirms, that this allay, notwithstanding it contains arsenic, is sufficiently ductile and malleable, which is very remarkable. But if it contain too much arsenic, it is brittle, and blackens in its surface. Arsenic united with tin is partly reduced to a powder like ashes, in which much arsenic remains. The rest of the tin is very brilliant, foliated, and externally resembling zinc, without being possessed of any of its properties. Tin also becomes much harder and more sonorous by this union. Lead united with arsenic smokes and swells more quickly with a moderate fire than it does alone: a part of it is dissipated in form of a thick smoke; another part is changed into a glass of a reddish yellow color; and the remaining lead is brittle, and dark-colored. Arsenic unites with silver, and renders it brittle. It does the same to gold, and also deprives it of its color, rendering it pale. It unites very difficultly with cobalt, with which it forms a black, shining matter. Lastly, Mr. Gellert (from whom all this is extracted) says, that bismuth cannot be united with arsenic.

In this author's table of affinities, the metallic substances capable of uniting with arsenic are placed in the following order, which is the same as that for the regulus of antimony: zinc, iron, copper, tin, lead, silver, gold, regulus of antimony.

The allays of arsenic used in the arts are white tombacs, and some compositions for speculums.

It is necessary to remark on the subject of arsenical allays, that this singular substance has the property of uniting with metals even when deprived of phlogiston, and in an unmetallic state. This proceeds from its saline character, and from its property of taking phlogiston from the imperfect metals and from the semimetals; consequently there ought to be a difference betwixt the allays made with white crystalline arsenic, and those made with the regulus of arsenic. See **ARSENIC**, and **REGULUS of ARSENIC**. (z) It is proper to observe, that chemists who treat of metallic allays differ much from each other in the descriptions they give of the results of their experiments, as may be seen in the particular articles of each metallic matter, which ought to be consulted on this subject. But these varieties are not surprising, when we consider the difficulty of the matter, and the great obstacles which prevent perfect exactness in these experiments. All who have operated much in chemistry will easily perceive, that, without reckoning the difference of proportions of the metals employed in the allays, which must greatly affect the results, others much more considerable would occur, depending on the purity of the metals, on the greater or less quantity of phlogiston with which many of them are capable of being united, on the very variable destructibility and volatility of many metallic matters, and lastly, on the just degrees of heat, which are of considerable consequence, and which it is almost impossible to determine precisely.

From these observations we ought to conclude, that, in order to make a set of accurate experiments on metallic allays, and which may be depended upon, it is, in the first place, necessary that all the metallic matters to be employed be exceedingly pure, which is a matter of great difficulty: in the second place, it is proper to make all the fusions in vessels perfectly close, to prevent the alteration, the burning, and the destruction of those metals which are liable to those events: lastly, to determine carefully the precise degree of heat requisite for the best combination of metallic matters with each other. But it does not appear that any person has hitherto done this great and important work; it is to be wished that it was undertaken. How many fine experiments may then be made upon all these allays, to discover their properties!

What has been already done in this matter is, however, sufficient to establish some general truths. Several have been explained in the beginning of this article. Another evidently results from the experiments of M. Kraaft and M. Geilert: it is this, That as the union of all other bodies, so in that of metallic substances, some are more easily soluble, and in all proportions; others more or

(z) The author of the Dictionary has omitted, in the enumeration of allays, those of platina, and of the semimetal discovered by Mr. Cronstedt, called *Nickel*. For those of platina, see the article **PLATINA**. *Nickel* may be allayed with all metallic substances

excepting silver, mercury, and zinc. By means of nickel the two semimetals bismuth and regulus of cobalt may be united. It whitens copper and gold, and it renders the malleable metals hard and brittle.

less difficultly, and only in certain proportions; and lastly, others appear incapable of uniting in any manner.

On these two latter cases it is very important to observe, that this property which certain metallic matters have of dissolving others in certain proportions only, is very capable of imposing on the operator, and of persuading him that one metal cannot be united with another, because he sees after the fusion two distinct reguli, while in fact there is a quantity, though frequently a very small one, of one of the metals united with the other. This is similar to what happens in the combination of spirit of wine with oils, and of water with ether. Chemists believed long that ether was insoluble in water, because when these two liquors were put in the same vessel they constantly separated, the ether, being greatly the lighter of the two, rising upwards, and floating on the surface of the water. But the Count de Lauragais, having examined the matter more attentively, and in a truly chemical manner, demonstrated, in a memoir read at the Academy of Sciences, of which he is a member, that ether is really soluble in water, but only in a certain proportion. *See ETHER.* This being established, perhaps we should find, if we were to examine all the mixtures of metallic substances, that those which have hitherto been considered as incapable of union are, nevertheless, very capable of it, but only in certain proportions; and if some are found which cannot by ordinary fusion be united, we might still try to break their aggregation more completely, and to apply them to each other in this condition, as the Count de Lauragais has done with sulphur and spirit of wine. *See COMBINATION; COMPOSITION (CHEMICAL).*

**XXXVIII. ALUDELS.** Chemists give this name to certain pots or capitals which are open at both the upper and lower ends, and may be inserted and applied above each other, so that the whole shall form a pipe or tube more or less long according to the number of aludels composing it. The aludel which terminates this tube above ought to be closed in its upper part, or to have but a very small opening. The tube composed of these aludels is nothing but a kind of capital or head, which may be enlarged or lengthened at pleasure, and adapted to a cucurbit. This apparatus is intended to collect and retain dry and volatile matters, which may be reduced into flowers by sublimation. It may be employed for the preparation of flowers of sulphur, of arsenic, of antimony, of benjamin, &c. *See SUBLIMATION. See also PLATES.*

**XXXIX. ALUM.** Alum is a crystallizable salt composed of vitriolic acid united with an argillaceous earth. This salt has an austere, sweetish, and strongly astringent taste. This strong taste proceeds from the strength of union betwixt the acid and its base being less than in other vitriolic salts with earthy bases; such, for example, as selenites, which has no sensible taste. Mr. Beaumé has even observed, that the acid of alum is not exactly saturated; for it is certain that it reddens turnsol and blue paper.

This salt dissolves sufficiently well in cold, but in much larger quantity in boiling water. (a) It is consequently susceptible of crystallization by the evaporation and cooling of the water in which it is dissolved. The figure of the crystals of this salt varies, like that of other salts, according to the circumstances concurring during the crystallization. When its solution, evaporated to the crystal-

(a) Neuman says, that alum requires ten times, and other authors say requires fourteen times, its weight of water to dissolve it.

lizing point, is made to cool slowly, the greatest part of its crystals are found to be triangular pyramids, whose four angles seem cut off. Alum retains half its weight of water in crystallizing.

This great quantity of water in the crystals of alum, together with its property of greater solubility in hot water, is the cause that when put in an earthen or iron vessel, on a good fire, it enters into a liquefaction, which gradually diminishes as the water evaporates. When it is entirely evaporated, which is not soon, the alum which had swelled much during this operation, remains dry and friable; it is then called *Calcined Alum*. After this evaporation, it may be again dissolved in water, and crystallized as before.

Although the acid of alum appears, as its taste and solubility indicate, to be less intimately combined with its basis than the acid of selenites, yet but a very small quantity of it can be disengaged by the strongest fire. Mr. Geoffroy put some calcined alum into an earthen retort, and exposed it to a most violent fire continued during six days and six nights; and from five pounds of alum thus treated he obtained only three ounces of vitriolic acid, although it is certain that this salt contains a much greater proportion of acid, as we shall soon see. The acid thus obtained by distillation from alum is called *Spirit of Alum*; and does not differ from pure vitriolic acid.

Alum may be easily decomposed by several intermediate substances.

First, as the acid of alum is certainly the vitriolic, all substances which have a greater affinity than earths to vitriolic acid, are capable of uniting with it, and of separating from it its earthy basis.

Alum, therefore, treated properly with any matter containing phlogiston, may be decomposed; its acid uniting with it, and forming artificial sulphur. See SULPHUR.

It is by means of this artificial sulphur, which forms during the calcination of alum with any vegetable or animal matter, that the *pyrophorus of Homberg* is made, which has the property of burning merely by contact of air. See PYROPHORUS.

In the second place, all saline alkalis are capable of decomposing alum. This decomposition may be made in the humid way. If then any alkali be added to a solution of alum, the liquor immediately becomes turbid and white, and a sediment is formed, which is the earth of alum separated from its acid by the intervention of alkaline salt. On the other side, the new salt formed by the union of the acid of alum with the alkali, may be crystallized by evaporating the liquor. If fixed vegetable alkali was employed for this precipitation, vitriolated tartar is formed: if mineral alkali was employed, Glauber's salt is formed. This decomposition of alum is a very convenient method of preparing these two salts. Lastly, if volatile alkali be employed for this precipitation of the earth of alum, vitriolic ammoniacal salt will be formed.

Calcareous earths, and even some metallic substances, are capable of decomposing alum. The former are so, because their affinity is greater than that of the argillaceous earth of alum with the vitriolic acid; and the latter, for instance iron and zinc, are so, because of the slight adhesion of their phlogiston.

It appears that Mr. Geoffroy was the first who discovered that iron could decompose alum; and this he did by boiling alum in an iron pot. This experiment of Mr. Geoffroy is found in the Memoirs of the Academy of Sciences.

What



What has been said concerning these different decompositions of alum proves incontestably, that the acid of this salt is the pure vitriolic; and this truth has been known a considerable time; but till lately, the nature of the earthy basis of alum was not precisely and distinctly understood. For a long time it was considered by chemists as a calcareous earth: but accurate experiments have since shewn, that calcareous earths, united with vitriolic acid, formed selenites and not alum, which are entirely different; and that the earth of alum could not decompose sal ammoniac, nor be converted into quicklime, nor had any of the distinguishing properties of calcareous earth. These experiments have been made by Pott, Margraaf, and Baron. This last chemist, struck with the differences betwixt earth of alum and calcareous earth, and with the resemblance betwixt alum and most vitriolic salts with metallic bases, has given a Memoir to the Academy of Sciences, in which he conjectures that this earth of alum is of metallic nature.

On the other side, there were experiments which prove, that the earth of alum was contained in clays. Mr. Geoffroy and Mr. Hellot had said, that, by digesting clays with vitriolic acid, they had obtained salts of the nature of alum. Hellot, having employed a clay as an intermediate substance in the distillation of the ether of Frobenius, perceived that the vitriolic acid of this mixture had deprived the clay of all its argillaceous properties, by taking from it an earth, which being again separated from this acid by an alkali, had all the properties of pure clay. See *Memoirs of the Academy for the year 1739*. Mr. Pott, who quotes in his *Lithogæognosia* this experiment of Mr. Hellot, having satisfied himself with regard to the properties of the alum obtained by digesting vitriolic acid upon clay, had concluded that the earth of alum is of an argillaceous nature. See *Pott's Lithogæognosia*. Mr. Gellert in his *Metallurgic Chemistry*, and especially Mr. Margraaf, in three dissertations upon alum, had mentioned the same experiments, and had drawn from them the same conclusions. Lastly, Mr. Macquer, in a Memoir read at the Academy in 1762, concerning clays and their fusibility when joined to calcareous earth, after having quoted the above citations, which are extracted from that memoir, places the affair beyond doubt, by adding his own experiments and observations to those already made. I add," says this chemist, "to all these testimonies, that having made an accurate examination of the properties of the earth of alum, separated from every acid, I am convinced, by all the proofs to which I have submitted it, that it has an entire and perfect resemblance to the purest clay: that is, to clay perfectly separated from vitriolic acid and all sandy matter. I have observed, that earth of alum, properly prepared, has all the argillaceous properties attributed to it by the above-mentioned chemists, and particularly a very binding quality. I have also observed, that this earth is very difficultly dried, and that it strongly retains the last portions of moisture. By drying, its bulk is considerably diminished, which occasions it to be much cracked. It receives a polish, like all fat clays, when rubbed with a smooth body. If it be exposed suddenly to fire before it be perfectly dried, it decrepitates strongly, and bursts with great noise, like clays. When it has been gradually heated, and then exposed to a violent fire, I have observed that it has acquired a flinty hardness, and that by this baking and hardening in the fire it has contracted to one half in all its dimensions.

“ Notwithstanding

“ Notwithstanding this hardening, and great contraction of its size by fire, it is remarkably refractory. It resisted the greatest violence of fire that I was able to expose it to without shewing the least tendency to melt. Having mixed it with fritts of crystal-glass, and different fluxes, such as fixed alkaline salts, nitre, borax, glass of lead, I have found that these matters melted and vitrified, without melting this earth; so that it has always communicated an opacity to all the glasses resulting from these mixtures.

“ A very remarkable property of this earth, but which, like the foregoing properties, is common to it with clays, particularly when very pure, is, that though its color be very white, yet this whiteness cannot be preserved: for when it is moist it greedily absorbs all greasy, and consequently coloring particles from contiguous bodies. When exposed to moderate fire, it begins to blacken; then it becomes more or less white, according to the nature of its coloring matter: but to whiten it thus, it ought not to be entirely closed, but to have a free communication with external air. Lastly, if the fire be increased sufficiently to harden well and bake this earth, then in whatever manner, and with whatever attention it may have been prepared, it never fails to resume so much more color as it is heated more intensely. It takes all sorts of tints, yellowish, greenish, bluish, grey, brown; and some I have seen become quite black. I have already observed, that the same thing happens to natural clays, when well deprived of sand.

“ This property denotes a very great disposition in this earth of uniting with the principle of inflammability, and of retaining it strongly when once united. This may give occasion to conjecture that the earths of metals, and those which are disposed to metallisation, are essentially of argillaceous nature; and this idea adds a new probability to the opinion of Mr. Baron, who, in a memoir upon the earth of alum, conjectures that this earth is of metallic nature, although not really reducible into metal, at least by any processes hitherto ascertained, and sufficiently known.

“ However that be, it appears well ascertained by the chemical experiments quoted above, and by mine, that earth of alum is a pure clay, free from all mixture of vitrescible earth; and that all natural clays are mixtures of greater or less quantities of this pure argillaceous earth, which is capable of combining with vitriolic acid, and of forming with it alum; and of another substance of different nature, which in its natural state cannot combine with vitriolic acid, and which Mr. Margraaf considers as a true sand, as indeed it has all the marks of that kind of earth.

“ From all this it may be inferred, that in all natural clays there is only this portion capable of forming alum with a vitriolic acid, which is a true argillaceous earth; and that the other portion is of a nature entirely different.”  
See CLAY.

Alum is capable of decomposing nitre and common salt, in consequence of the vitriolic acid it contains. The nitrous and marine acids may even be obtained more pure by means of alum than of any other substance.

All the alum which is in commerce is extracted by different operations from several pyritous, earthy, or stony matters, containing the vitriolic acid and the earth proper for forming this salt.

The

The pyrites or pyritous matters from which alum is extracted, ought to have effloresced in open air, or to have been calcined in the fire, to allow the vitriolic acid of the sulphur which they contain to disengage itself. This acid meeting in the pyrites itself the argillaceous earth proper to form alum, does in fact there combine with it and form that salt; which is afterwards extracted by lixiviation, evaporation, and crystallization, as is practised for all salts. Much of these pyrites or pyritous stones furnishing alum are found in Sweden, England, Germany, and France, and they are worked by the general processes we have mentioned. But to have a clear idea of what passes in these operations, it is necessary to know pyrites, and its nature; for which reason see the word PYRITES.

**XL. ROCK-ALUM.** The alum which is extracted from pyritous mineral matters is seldom very pure, on account of the vitriolic metallic substances always contained in pyrites. I have examined many of these alums, and by the proofs made of them, I have found that they always contained a greater or less quantity of martial vitriol. This alum is in commerce called rock-alum, because much of it is extracted from pyritous rocks or stones. It appears that the names *Ice-alum* and *Rock-alum* are synonymous and confounded in commerce, because there is no difference in the price. Frequently these alums, which are in great masses, like stones, (which may also have contributed to the name Rock-alum) have a reddish tinge. These are the impurest, and contain most martial vitriol.

A large quantity of pure alum is extracted from the neighbourhood of Puzzoli, near Naples, at a place called *Solfatara*. See SULPHUR.

The Abbé Nollét, who visited this place, and examined the works established there, says, in the Memoirs of the Academy, that the matter from which the alum is extracted, is an earth similar in its consistence and color to the marl found in the same plain. I have examined this earth, and have found that it has the appearance, and nearly the consistence of white marl: but it differs essentially from marl in not effervescing with nitrous acid.

Caldrons of lead, two feet and a half in diameter, and as much in depth, are filled with this earth or stone to three quarters of their contents. These caldrons are sunk so as to be almost on a level with the ground under a great shed, at about the distance of four hundred paces from the sulphur furnaces. Water is thrown into each caldron, till it rises three or four inches above the earth. The natural heat of the ground of this place is sufficient to heat the matter, as it makes Mr. Reaumur's Thermometer rise thirty-seven degrees and a half above the freezing point: and thus fuel is spared. By means of this digestion, says the Abbé Nollét, the saline part is disengaged from the earth, and rises to the surface, whence large crystals are extracted.

The alum in this state is mixed with much impurities. It is carried to a building at the entry into the Solfatara, and it is dissolved with hot water in a great stone vessel shaped like a funnel. The alum is there crystallized again by the heat only of the ground, and becomes purer.

**XLI. PLUME-ALUM.** This name is given to two very different substances. One is a matter truly saline, which tastes and dissolves in water like alum, and crystallizes in form of feathers. This kind of alum, which is native, is found crystallized in grottos where aluminous mineral waters pass. Mr. Tournefort observed it in his voyage into the Levant. It is rare, and not found

found in commerce. The other matter to which the name of plume-alum has been very improperly given, is nothing else than a *friable amianthus* or *asbestos*. (b)

**XLII. ROMAN ALUM.** In the territory of Civita Vecchia, about fourteen leagues from Rome, is found a hard stone whence a great deal of very fine and pure alum is extracted. The place where this stone is found and manufactured, is called *Aluminera della Tolfa*. This stone, which is neither pyritous nor calcareous, is manufactured by calcining it, as limestone is, for twelve or fourteen hours, after having broken it in pieces. This stone thus calcined is laid in several heaps upon places surrounded by ditches filled with water. It is sprinkled with this water three or four times each day, for forty days, or till the calcined stone enters into a kind of effervescence, and is covered with a reddish efflorescence. Then the stones are boiled with water, in order to dissolve all the alum which is formed, and the water is then evaporated to the point of crystallization. This water is made to flow quite hot into broken vessels, where, by cooling, a great quantity of irregular crystals are formed of a pale reddish tinge. In this state the Roman alum is sold. It is not in large masses like rock-alum, but in lumps of the size of almonds, nuts, or eggs. This alum is also mixed with much reddish dust. I have carefully examined the purity of Roman alum, and I have found it to exceed much the purity of rock-alum. It contains no metallic or vitriolic matters; and is therefore preferred for certain dyes, the beauty of which is hurt by the smallest quantity of martial vitriol. Its price also is greater than that of rock-alum. (c)

Alum is very useful in several arts, and chiefly in dying, to which it is essentially necessary, as it heightens the intensity and lustre of most colors. It is even absolutely necessary to give solidity to all those colors which reside in gummy substances. Without alum, these dyes would be only confused stains, which might be washed out by water. See DYING.

Alum is an astringent drug of powerful efficacy; consequently it is proper for diseases where the principal indications are to fortify and constringe, as

(b) Alum is sometimes found native with a lanuginous or plumose appearance, and it is then called *plume alum*. It is probably formed by the decomposition of pyrites, or some compound containing sulphur, and clay. By the dissipation of the phlogiston of the sulphur, the vitriolic acid is disengaged, and unites with the argillaceous earth, forming alum.

The name *plume-alum* is also frequently given to a striated stone of the asbestos kind, called also *false asbestos*. See ASBESTOS.

Lastly, this name is given by Basil Valentine, and other alchemical authors, to a compound formed of arsenic united with vitriolic acid.

(c) A remarkable circumstance attends the crystallization of alum, namely, that good

crystals of this salt cannot be formed, unless an alkaline lixivium or urine be added to the lixivium of alum when set to crystallize. Chemists supposed that by adding these alkaline matters, some metallic or impure earthy substance which prevented the crystallization was precipitated; but Mr. Margraaf found by experiments that he could not form good crystals by combining vitriolic acid with earth of alum, with calcined alum, or with clay, unless he added a lixivium of fixed or volatile alkali, or urine. He supposes that these alkaline lixiviums produce their effect either by engaging a superabundant acid, or some greasy matter which prevents the crystallization.

for immoderate menstrual and lochial discharges, losses of blood, fluor albus, diarrheas, hemorrhages, vomitings of blood, and even some kinds of hemoptoes. But it is necessary to observe on the subject of this remedy, and even of all other astringents, that they ought only to be prescribed by intelligent physicians, who can distinguish whether or not these diseases proceed from or are accompanied with inflammation, or too great plenitude : for in these cases, astringents, so far from being useful, must be pernicious, and increase the cause of the evil. Alum is improper in these maladies, but when it is evident that they proceed from a mere relaxation, or from a rupture of the vessels : in these cases it has excellent effects.

Alum is one of the strongest astringents, and as it is even somewhat caustic, several intelligent physicians, as Mr. Cartheuser, and Mr. Baron, in his *Notes on Lavoisier's Chemistry* prohibit the internal use of it ; notwithstanding which it is every day used successfully in the above-mentioned cases. However, it is prudent to administer alum at first in very small doses only, as two or three grains except in very urgent cases, where it may be given to ten or twelve. It may be given either alone, or joined with other astringent or blunting medicines, according to the particular indications.

Alum being susceptible of decomposition by all alkaline and calcareous matters, it must not be mixed with these substances, when intended to act as an astringent. Alum is often used externally ; it constricts and fortifies considerably the parts to which it is applied : consequently it is an efficacious repellent, and is useful in collyriums and in astringent gargarisms. When calcined, its powder is sprinkled on soft and fungous flesh, which prevents the cicatrification of ulcers. It absorbs their moisture, dries and consumes them.

**XLIII. ALUMINOUS.** Whatever contains alum, or partakes of the nature of that salt is called aluminous.

**XLIV. ALKANET.** (d)

**XLV. ALMONDS.** (e)

**XLVI. ALOES.** (f)

**XLVII. ALTHEA.** (g)

(d) **ALKANET.** The cortical part of the root of this plant, which is a kind of Bugloss, contains a red colorific matter, capable of being extracted by oils, by wax, and by spirit of wine. Wax thus colored, applied to warm marble, leaves a red stain.

(e) **ALMONDS,** *sweet* and *bitter*, contain an expressible oil and farinaceous earth. The bitter part of bitter almonds is not expressed with the oil, but may be dissolved by digestion in aqueous and in spirituous liquors, and with these may be distilled. Waters distilled from bitter almonds, or from most other bitter vegetables, fruits, and flowers, which have a similar flavor to them, are poisonous to birds, to some animals, and have sometimes been so to men.

(f) **ALOES** is an inspissated bitter juice extracted from the leaves of a plant of the

same name. It is partly gummy, and partly resinous ; and the gum and resin are so well mixed together, that most of the juice is soluble either in aqueous or spirituous menstrua.

(g) **ALTHERA,** or *Marsh-mallow*. Two ounces of the root of althea yielded, with water, ten drams and fifty grains of mucilaginous extract ; and afterwards, with spirit, forty-one grains of resin. The same quantity of that root treated first with spirit gave six drams of a resinous extract, a considerable part of the mucilage dissolving in that menstruum along with the resin. The remainder boiled in water gave five drams and forty-eight grains of pure mucilage. The insoluble earthy part was one-fourth part of the root, and one half of the leaves of althea. *Neuman.*

**XLVIII.**

**XLVIII. AMALGAM.** This word is applied to the alloys of metallic matters with mercury.

Mercury being a metallic substance cannot contract any union with earthy matters, not even with the earths of metals when deprived of their phlogiston, and their metallic form. But it is capable of being alloyed more or less easily with almost all metallic substances.

As mercury is habitually fluid, as it ought to be considered as a metal perpetually in fusion, and as it is sufficient for most combinations that one of the two bodies that are to be combined be fluid, it follows that without the help of heat, mercury may be amalgamated with many metallic substances. There are two methods generally used of making amalgamas. The first is merely by trituration, and without heat. The second is by fusing the metal which is to be amalgamated, and by adding to it, when fused, the intended quantity of mercury.

Metals, by their union with mercury, become friable and capable of being pulverized, when the mercury is only in small quantity. But when the mercury is added in larger quantities, the metals are by it reduced to kinds of paste, which has no ductility nor tenacity.

Of all metals, gold has the greatest affinity to mercury, and unites with it most easily. For this purpose nothing more is requisite than that the mercury should be slightly rubbed on a piece of gold, or that it remain some time in a golden vessel. The surface of the gold which has touched the mercury becomes white as silver; and if the gold is thin, its consistence is destroyed in that place, so that it very easily breaks. But the amalgamation of mercury with gold is considerably accelerated by dividing the gold into very small parts or very thin plates. All metals ought to be so divided, when they are to be amalgamated by trituration without fusion or heat. (b)

Silver may be amalgamated nearly in the same manner as gold. Mr. Gellert has observed a singular and remarkable phenomenon in this amalgam, which is, that its specific gravity is not only greater than the intermediate specific gravity of the mercury and of the silver, but that it is even greater than the specific gravity of mercury, although silver be greatly lighter. See SILVER and MERCURY.

Mr. Gellert ascertained this fact, not only by observing that the amalgam of silver sinks to the bottom of a vessel containing mercury, but also by the exact hydrostatical experiment. See his *Metallurgic Chemistry*. Tom. I.

The amalgams of gold and silver, and particularly the first, are much used for the separation of these two metals from their ores, or rather from the earthy

(c) As an amalgam of gold is much used for separating metals, we shall mention that the pieces or grains of that metal may be more easily and perfectly amalgamated by applying them first to the mercury, which ought also to be previously heated till it begins to smoke, and by stirring the mixture with an iron rod till the gold disappears, which will be very soon. When the quantity of mer-

cury is so large that the mass is fluid when cold, the superfluous part of it may be separated by passing it through soft leather: this contains a very small portion of gold. The remaining amalgam has the consistence of butter, and contains about one part of mercury to two parts of gold, but is nearly as white as silver.

and

and stony matters with which they are mixed. See ORES of GOLD, and of SILVER. These amalgams are also used for some kinds of *gilding* and *silvering*. See these two words. The amalgam of silver is also employed for the *Arbor Diane*. See ARBOR DIANE.

The amalgamation of all metals with mercury is much facilitated by heat. But the amalgamation of those metals which unite difficultly with mercury cannot be effected without heat. For this purpose, the mercury ought to be heated till it begins to rise in vapors; and the metals of difficult fusion, which we suppose to have been previously divided into small parts, ought to be made red by fire, and quickly triturated with the hot mercury. As to the metals which melt before they become red, such as tin and lead, it is sufficient to melt them, and to throw the mercury upon them, stirring a little the mixture: and thus the amalgam is made in an instant.

It would be very imprudent to melt metals which require a great heat for their fusion, as copper, for instance, and to add mercury to this melted metal, with an intention to make an amalgam; because not only the greatest part of the mercury would be dissipated in vapors before it could be united to the metal, but also because there would be great danger of explosion from the mercury, which being a rarefiable and volatile body, is capable, like all such bodies, of producing this effect, when they are suddenly exposed to too great heat.

Mercury amalgamates difficultly with copper, more difficultly with regulus of antimony, not at all with iron (*i*), nor, as Mr. Gellert says, with cobalt. But with all the other metals and semi-metals it may be easily amalgamated.

The amalgam of mercury with tin is much used for covering one of the surfaces of mirrors, and thus rendering them capable of representing images more sensibly and perfectly. See TINNING of LOOKING-GLASSES. This amalgam is also used for the preparation of mercury-balls, intended to purify water. See BALLS (MERCURY).

Bismuth when amalgamated with mercury has the singular property of so attenuating lead added to this amalgam, that a great part of this metal may be passed through leather along with the mercury. Mr. Cramer advises, in order to make this experiment succeed, to melt the lead first with the bismuth, and to this mixture to add the mercury. He further says, that if this amalgam be digested several days, the bismuth will be separated, and will leave the attenuated lead united to the mercury.

Regulus of antimony can, as was said above, very difficultly, be united with mercury. Mr. Gellert says, that to make this amalgam succeed, the regulus ought to be put into hot mercury, and the whole covered with water. But that when the regulus of antimony has been prepared by means of iron, or an alkaline earth, this amalgam may be made much better, so that the regulus shall not separate, after standing some time, from the mercury, as it usually does.

(*i*) Dr. Lewis observes, that mercury adheres to, and coats the ends of iron pestles used for the trituration of amalgams, and that a plate of tough iron may be rendered brittle by keeping it immersed in mercury during some days. This experiment did not succeed with me. Hence he infers, that mercury is not incapable of acting upon iron.

The affinities of metallic substances with mercury are placed, according to Mr. Geoffroy, in the following order : gold, silver, lead, copper, zinc, regulus of antimony.

According to Mr. Gellert's table, they are, gold, silver, bismuth, zinc, tin, lead, copper, regulus of antimony.

As the amalgams of mercury are true allays of metallic substances, all the general properties of allays are applicable to them. See ALLAY.

#### XLIX. AMBER. See BITUMEN.

L. AMBERGRISE. Is a substance of a grey color, which most chemists and naturalists have classed amongst bitumens, rather from its properties and the principles, it yields by distillation, than from any certain knowledge of its origin. For it does not appear that any truly fossil ambergrise is known, and that any is found in commerce, but what is procured from the Indian seas upon which it floats in the neighbourhood of the Molucca islands.

Mr. Cartheuser thinks that ambergrise ought certainly to be considered as a bitumen; and he is determined to this opinion from the analyses made of it by several chemists, and particularly by Neuman. From which analyses it appears, that the same principles were obtained from ambergrise as from amber, that is to say, phlegm, a volatile acid, partly fluid and partly solid, oil, and a little coaly matter.

Besides, ambergrise is nearly as difficultly soluble as amber and other bitumens in different menstrua: but it differs from amber in this, that it is much softer, is not smooth, nor is capable of taking a polish. Further, it is not transparent, and is capable of fusion. The heat of the hands alone is sufficient to soften it like wax. It also leaves much less coaly residuum than amber, after distillation. All these properties denote that ambergrise is much more oily than amber.

The agreeable smell of ambergrise renders it useful in perfumes. Musk however is always joined with it, or substituted for it; not because musk is cheaper, for it also is very dear, but because its smell is greatly stronger, and goes farther in the preparation of perfumes.

Ambergrise is also useful in medicine. It has the same general virtues as all the odoriferous substances, from the spiritus rector or highly attenuated and volatile oil, which is the principle of their smell. It enters into the composition of many cordial, sudorific, and alexiterial waters. It is also said to be a venereal stimulant. But its chief virtue consists in its antispasmodic and sedative qualities similar to those of musk and castor, and in its power of relieving certain hysterical, convulsive, and other nervous affections. It may be taken inwardly from half a grain to ten or twelve grains or more. For, as to doses, there can be no fixed rules about remedies and diseases of these kinds.

LI. AMMONIAC (SALT). All neutral salts composed of any acid saturated with volatile alkali, may be called ammoniac salts. But the name *Sal-ammoniac* is more especially appropriated to the neutral salt resulting from the union of the acid of common salt with volatile alkali. All the other ammoniacal salts are specified by particular epithets, as *vitriolic ammoniacal salt*, *nitrous ammoniacal salt*, and *vegetable ammoniacal salt*. We shall speak successively of these several salts.

All ammoniacal salts have the general properties of neutral salts, composed of acids and alkalis. But they differ from the neutral salts whose bases are fixed



fixed alkalis, by their more pungent taste, which proceeds from the less adhesion of acids in general with volatile alkali than with fixed alkali; in the second place, by their less fixity, all the ammoniacal salts being semi-volatile, that is, capable of subliming to a certain height, when exposed to a strong enough fire. This property proceeds from the volatility of their alkaline bases. Lastly, ammoniacal salts are susceptible of decomposition by many substances not capable of producing the same effect on neutral salts whose bases are fixed alkali; as we shall see by a more particular examination of the properties of these salts.

The most generally known and used ammoniacal salt is that which contains the acid of common salt. This salt, when very pure, is very white, semitransparent, capable of forming feather-like crystals, or of subliming in close vessels into a compact striated mass.

This salt is easily soluble in water. It deliquesces into a liquor when exposed some time to a moist air. It is one of the salts which produce the most cold during its solution in water. This generation of cold is so much as to sink the thermometer eighteen or twenty degrees, and even more, according to the temperature of the atmosphere. It appears that the hotter this temperature is, the greater cold is generated, which proceeds from the greater and quicker solubility of this salt in warm than in cold water. Mr. Gellert [*Metallurgic Chemistry*, tom. 1.] says, that if any gum or resin be boiled in water impregnated with sal ammoniac, these substances will be dissolved in it. It is not surprising that gums should be thus dissolved, considering that water is their proper menstruum. But as pure water does not at all attack resins, their solution in Mr. Gellert's experiment must proceed from the sal ammoniac.

Sal ammoniac cannot be decomposed merely by the action of fire in close vessels; because it then entirely sublimes, as we have already observed. To decompose it therefore, we must employ some intermediate substance capable of disengaging either its acid or its alkali.

The acids having, from their several affinities, the same relations to volatile alkali as they have to fixed alkali, (*See ALKALI VOLATILE*) it follows that sal ammoniac ought to furnish the same phenomena of decomposition by the vitriolic and nitrous acids, as common salt does. These two acids then are capable of decomposing sal ammoniac, by separating its acid, which passes alone in distillation, and by uniting themselves with the volatile alkali, with which the first forms a vitriolic ammoniacal salt, and the second a nitrous ammoniacal salt.

It is proper to observe upon the decomposition of sal ammoniac by nitrous acid, 1. That the marine acid does not rise singly in distillation, but is always accompanied with a good deal of nitrous acid, which rises in consequence of its volatility, and, together with the marine acid disengaged from the sal ammoniac, forms an *aqua regia*. 2. That in this operation great management, slowness, and precautions are necessary, particularly if smoking spirit of nitre be employed; because the vapors which pass are more expansible, and less condensible than the pure vapors of the nitrous or of the marine acids, which difference undoubtedly proceeds from the reaction of these two acids upon each other. 3. That it is very necessary to attend carefully to the fire towards the end of the distillation, and when the matter remaining in the retort begins to be dry; because it is a nitrous ammoniacal salt, which has the property of detonating alone, and with

little

little heat. Prudence therefore requires that the distillation be not pushed to perfect dryness. There is scarcely any operation in chemistry so liable to an explosion as this is. See **AMMONIAC (NITROUS SAL)**.

Sal ammoniac is also capable of decomposition by many substances, which, by uniting with its acid, set at liberty its volatile alkali.

These substances are calcareous earths, quicklime, fixed alkalis, and metallic matters. The most essential phenomena which this salt exhibits, when treated by these different matters, are the following:

If powdered sal ammoniac be mixed with twice its weight of any calcareous earth, of chalk for example, also powdered, and the mixture be distilled with a proper apparatus, (See **DISTILLATION**) a large quantity of volatile alkali will pass into the receiver, in a concrete form, very white and very beautiful, lining all the inside of the receiver; and when the operation is over, we shall find in the retort a mass containing all the acid of the sal ammoniac, engaged and retained in the calcareous earth; if consequently this caput mortuum be lixiviated, in order to dissolve all its saline part, we shall find that this lixivium is impregnated with much marine salt with earthy basis. See for the properties of this salt **ACID (MARINE)**, and **SALT (MARINE) with EARTHY BASIS**.

In this operation a true decomposition happens of the sal ammoniac by the intervention of the calcareous earth. Mr. Duhamel seems to have been the first who discovered and published this decomposition. He has observed, that the volatile alkali of the sal ammoniac, when it disengages itself in this operation, carries off with it a part of the calcareous earth. We shall soon see that it also carries off part of other substances employed to disengage it.

Mr. Beaumé, who has since repeated this experiment with his usual accuracy, and in great quantities, has observed, that a quantity of volatile alkali may be obtained by this distillation equal in weight to the sal ammoniac employed, altho' it be certain, that there is nearly as much marine acid as volatile alkali contained in sal ammoniac. (k)

This salt treated with quicklime is still more easily decomposed than with uncalcined calcareous earth. To make this decomposition, and to obtain the volatile alkali, powdered sal ammoniac must be quickly mixed with twice its weight of quicklime, flaked by exposure to air, and the mixture must be quickly put into a great stone-ware retort, to which a receiver must be immediately

(k) Mr. Duhamel and other authors have attributed this great increase of weight gained by volatile alkali, during its separation from the marine acid in the decomposition of sal ammoniac, by intervention of chalk, or other mild calcareous earth, or mild fixed alkali, to part of the substance of the earth, or fixed alkali, being carried along with the volatile alkali. The substance which volatile alkali does receive from these intermediate matters is not, as these authors have supposed, earthy, or alkaline, but is the fixable air which is separated from them, when they combine with the acid of the sal ammoniac. In this operation, therefore, we

have an instance of what our author calls *double affinity*; (See **AFFINITY**) the acid of the sal ammoniac combining with the earthy part of the chalk, or with the saline part of the mild alkali, and the volatile alkali of sal ammoniac combining at the same time with the fixable air of the chalk, or of the mild alkali. That this addition of fixable air to the volatile alkali is sufficient to render its weight equal to that of the sal ammoniac employed, appears from Mr. Cavendish's experiments, which shew, that more than half of the weight of mild volatile alkali is fixable air. See **AIR (FIXABLE)**, and **ALKALI (VOLATILE)**.

luted

luted. *See* DISTILLATION. The action of the quicklime upon the sal ammoniac is so quick, that a good deal of volatile alkali is disengaged as soon as the two matters are mixed together, which obliges the operator to take care not to expose himself to breathe the vapors. The heat must also be attended to in this distillation, particularly at the beginning, because then it is performed almost without fire.

It is very remarkable that volatile alkali, obtained by intervention of quicklime, never is, nor can be, in a concrete form, by any method. It is always liquid, and is called *volatile spirit of sal ammoniac*. It is evident that it is by means of the water contained in a large quantity in the slaked lime, and in which the volatile alkali is dissolved, that it thus appears in a liquid state; but it is certain that this saline matter so strongly adheres to this water, that it cannot be separated without some intermediate substance; and that, on the other side, this same water is so necessary to its separation from the marine acid by the intervention of the lime, that Mr. Duhamel could not obtain volatile alkali by trying to decompose sal ammoniac with quicklime in the state it is in when newly calcined, and still hot from the kiln, and consequently perfectly dry. (l)

This volatile alkali, although it be diffused in much water, is still more active and more penetrating than that which is obtained by the intervention of other substances in a dry and concrete state. Mr. Beaumé has observed, that the volatile spirit of sal ammoniac made with quicklime, when poured into a solution of any salt with earthy basis, does not produce the same effects as the same alkali of sal ammoniac which has been disengaged by calcareous earths or fixed alkalis, and which may always be procured in a concrete state; as this latter volatile alkali easily decomposes these salts with earthy bases, and occasions a copious white precipitate to fall from their solutions, while the former does not appear to produce any effect, but only occasions a very light whitish cloud. (m)

These differences prove that a singular alteration is produced upon volatile alkali by quicklime; and this alteration is probably caused by the quicklime depriving it of part of its inflammable principle by help of which it seems crystallizable, and consequently by a partial decomposition of it. Another phenomenon, no less important, supports this opinion; which is, that if volatile spirit of sal ammoniac be frequently distilled from new quicklime each time, we may easily perceive that there is a considerable quantity of it entirely decomposed by each

(l) The volatile alkali obtained by this process is caustic or uncombined with fixable air, and is therefore, as we have observed under the article VOLATILE ALKALI, always in a liquid state. This liquid volatile alkali may also be obtained by employing caustic fixed alkali instead of the quicklime. From Mr. Duhamel's experiment mentioned in the text, by which he found that volatile alkali could not be obtained in this process, unless water was combined with the quicklime, it appears probable, that this operation also is an instance of double affinity, and differing only from the former operation in this

respect; that in this process the volatile alkali receives water, and in the former it receives fixable air, from the calcareous earth.

(m) Caustic or uncombined volatile alkali does not precipitate calcareous earths from acids; because its power of combination with acids does not seem to be stronger than that of those earths. But mild volatile alkali acts upon salts with bases of calcareous earth, by what our author calls double affinity; that is, its alkaline part combines with the acid of those salts, while its fixable air combines with the calcareous earth.

distillation;

distillation; and that, on the other side, if, as Mr. Duhamel did, we lixivate quicklime in a large quantity of water, till it makes no longer cream of lime, nor has the properties of quicklime; and if the lime thus decalcined, and reduced to the state of mere calcareous earth, be employed for the decomposition of sal ammoniac, we shall then obtain a concrete volatile alkali, as if a calcareous earth had been used, which had never been calcined. See QUICK-LIME. (n)

When sal ammoniac is decomposed by the intervention of quicklime, in the retort is found a saline earthy matter; that is, a part of the quicklime above what was necessary for the decomposition, and another part saturated with the acid of sal ammoniac, and forming a sort of sea-salt with earthy basis, which seems to be similar to that salt formed by uniting marine acid with an uncalcined calcareous earth, but which ought to differ from it in many respects, and particularly by a stronger adhesion of the acid to the quicklime. (o) This salt, when dry, is called improperly *fixed sal ammoniac*, and when deliquated into a liquor, it is called *cil of lime*, or *liquid shell*.

Fixed alkali, either vegetable or mineral, easily decomposes sal ammoniac, and separates from it by distillation the volatile alkali in a concrete state, if there be little or no water in these matters: but if these matters contain water, or if water be designedly added, the alkali, which is more volatile than the water, passes first, partly in a concrete state, then the water which rises dissolves it wholly or partly, according to the quantity of water, and it is thus reduced to a liquid state. Mr. Duhamel observes, that in this distillation also the volatile alkali carries off with it a portion of the fixed alkali which is employed to disengage it. (p)

The salt remaining in the retort after this distillation is common salt, entirely similar to ordinary sea-salt, if the fixed alkali employed was the mineral alkali; and similar to regenerated sea-salt, or salt of Sylvius, if the vegetable fixed alkali was employed. See SALT (COMMON).

Most metallic substances also act upon sal ammoniac, and are capable of decomposing it.

Silver, copper, iron, tin, lead, and mercury, well mixed with this salt, and distilled together, disengage its volatile alkali. The semimetals also produce the same effect. After the distillation is finished, the metal is found combined with the acid of sal ammoniac. This silver becomes *luna cornea*, and lead becomes *plumbum corneum*. In this manner Mr. Margraaf prepared his *plumbum corneum* which he employed in his operation for phosphorus. See PLUMBUM CORNEUM; and PHOSPHORUS.

A remarkable thing occurs in this decomposition of sal ammoniac by lead, for which Mr. Margraaf requires a calx of lead, such as minium, rather than lead

(n) Mr. Duhamel evidently reduced his quicklime to mild calcareous earth, that is, combined it with fixable air; we need not, therefore, wonder that the volatile alkali which he obtained was also mild, or combined with that air.

(o) The salt formed by decomposing sal ammoniac with quicklime is precisely the

same as the salt formed by uniting marine acid with uncalcined calcareous earth: for the acid, uniting with uncalcined calcareous earth, deprives it of its fixable air, and reduces it to the same state as the calcined earth, or quicklime is in.

(p) See the note (i).

itself

itself, for the conveniency of the mixture; which is, that the volatile alkali which passes over in the distillation, altho' very strong and much dephlegmated, is always in a liquid or fluor state, which shews, that upon this occasion, as in many others, metallic calces produce the same effect as quicklime.

As to mercury, it very certainly decomposes sal ammoniac, and separates its volatile alkali. But if more sal ammoniac was added than the mercury can decompose, this undecomposed part of the salt remains united with the combination of marine acid with mercury, and cannot by crystallization or sublimation be separated from thence. This fact has been ascertained by Mr. Macquer; of which a detail is given in his *Memoir upon the Count de la Garaye's Tincture of Mercury*, printed in the collection of the Academy of Sciences in the year 1755.

Junker says, that regulus of antimony treated with sal ammoniac disengages the volatile alkali, and is converted into butter of antimony.

It is proper to observe on this occasion, of the decomposition of sal ammoniac by earthy and metallic substances, which unite with its acid and disengage its volatile alkali, that as the volatile alkali thus disengaged is capable of separating in its turn all these same substances united to an acid, and even to the marine acid, there seems to be something contradictory in the affinities of volatile alkali, and of earthy and metallic substances. Mr. Baron, in his *Memoir upon Borax*, and Mr. Macquer, in his *Elements of Practical Chemistry*, explain these effects in a plausible manner, by the great difference of the fixity and volatility of these substances. It appears nevertheless that the subject is still somewhat obscure, and requires a more particular examination.

If, instead of mixing with sal ammoniac sufficient quantities of copper, iron, and even of most other metals, and with proper circumstances for the decomposition, these metals were employed in a smaller quantity, and that the heat was immediately raised sufficiently intense for sublimation, the sal ammoniac would then be obtained sublimed, or flowers of undecomposed sal ammoniac would be raised, containing some part of the metals. By this method chemical preparations or medicines are made, which are named from the metals employed. Thus flowers of sal ammoniac impregnated with copper are called *ens veneris*; those impregnated with iron, are called *martial flowers of sal ammoniac*, or *martial flowers*, or *ens martis*. See these words.

There are also other properties of sal ammoniac which ought to be mentioned here.

This is one of those salts which are soluble in spirit of wine. Mr. Macquer, in the above quoted memoir, has determined that thirty-two parts of well rectified spirit of wine are necessary for the solution of one part of sal ammoniac.

Sal ammoniac acts considerably on mercury sublimated corrosive. It dissolves this salt and unites with it, and occasions no decomposition to either of the salts. From the union of these two salts, a mixed salt is produced which chemists have called *Salt Alembroth*. See this word.

Sal-ammoniac is employed advantageously in many arts. It is particularly useful in the tinning of copper and iron. See *TINNING*. It is also employed in the fusion of gold; because it has been observed to exalt and heighten the color of that metal.

If sal ammoniac be treated with nitre in a crucible, and with a red heat, the nitre is observed to deslagrate to a certain point. This phenomenon proceeds

from the inflammable matter which enters into the composition of the volatile alkali, which is the basis of the sal ammoniac. It is also this same inflammable principle which produces the good effects of sal ammoniac in the tinning of metals.

Sal ammoniac is found ready formed in volcanos, or in their neighbourhood. It is called *native sal ammoniac*; but it is in too small quantity to furnish the demands of artists. The sal ammoniac sold in commerce is made in great manufactories for this purpose.

The method of manufacturing sal ammoniac was long unknown. Mr. Le Maire and Mr. Granger were the first who explained the process, in very circumstantial memoirs upon this subject communicated to the Academy of Sciences. An extract of these memoirs may be found in Mr. Macquer's Elements of Practical Chemistry; for which reason, we will only briefly mention, that in Egypt, where most of the sal ammoniac is made which is in commerce, soot is employed for this purpose, which is produced by burning the dung of cows and camels, which are the ordinary fuels of that country. This soot is put into large glass vessels arranged near each other in oblong furnaces. The fire is raised gradually, that all the volatile principles of the soot may be driven off; then the fire is increased towards the end, by which the sal ammoniac is sublimed, the materials of which were contained in the soot; the glass vessels are then broken to get out the loaves of sal ammoniac, which are formed upon the upper interior parts of the glass vessels. These loaves or cakes, as they are found at the shops of druggists, weigh from three to five or six pounds. They are more or less blackened by a quantity of fuliginous or sooty matter, which rises with the sal ammoniac in the sublimation. See Soot.

Sal ammoniac may be purified from this extraneous matter by the means commonly employed for the purification of salts, that is, by dissolving in water, filtering, crystallizing, and by subliming a second time, if this should be thought necessary: a sal ammoniac is then obtained perfectly white and pure. Sal ammoniac may be made by combining marine acid to the point of saturation with volatile alkali, obtained from the distillation of animal or vegetable substances, and by filtering, crystallizing, and subliming the saline matters thus combined. But this sal ammoniac would cost more than the price it is generally sold for. Although the volatile alkali used for this process, solid or liquid, be very impure and impregnated with much empyreumatic oil, from which it is difficult to purify it, yet the sal ammoniac obtained from it by this method is very pure and good; because the volatile alkali, when it combines with an acid, separates it from all the superabundant oil with which it was at first combined: hence the volatile alkali obtained by decomposing sal ammoniac is better disengaged from all superabundant oily matter than what is obtained by any other method. But we must observe, that the volatile alkali obtained from sal ammoniac always carries off with it some of the substance employed for the decomposition. This circumstance must produce different effects in chemical experiments, to which attention ought to be given. (q)

- (q) To the above article we shall add;
1. Sal ammoniac requires four times its quantity of water to dissolve in that liquid,
  2. Its volatility is diminished so much by repeated sublimations, that it remains half fluid at the bottom of the subliming vessel; and when sal ammoniac was repeatedly sublimed together with mercury corrosive sublimate,

**LII. AMMONIACAL SALT (VITRIOLIC).** This is a neutral salt composed of vitriolic acid saturated by volatile alkali.

This salt may be made by several different methods.

1. By combining vitriolic acid with disengaged volatile alkali.
2. By decomposing sal ammoniac by vitriolic acid in Glauber's manner. If this latter method be used, a marine acid is obtained by distillation, strong in proportion to the concentration of the vitriolic acid employed; and in the residuum the vitriolic ammoniacal salt remains, which *Glauber* called his *secret sal ammoniac*.

3. By decomposing all vitriolic salts with earthy or metallic bases, by means of volatile alkali. See **ALKALI (VOLATILE)**.

This salt has the properties of sal ammoniac, with the differences depending on their different acids. It is semi-volatile; it may be entirely sublimed; it cannot be decomposed in close vessels without some intermediate substance; it has a sharp taste; it easily dissolves in water; and is susceptible of crystallization. This ammoniacal salt is not used in arts or in medicine. *Glauber* attributes many wonderful properties to it, which it certainly does not, so eminently at least, possess.

**LIII. AMMONIAC SALT (NITROUS).** This salt is composed of nitrous acid saturated with volatile alkali. It is found in earths, or plasters where nitrous acid is generated, when these earths have imbibed a sufficient quantity of putrid animal or vegetable substances to furnish volatile alkali to the generating nitrous acid.

Nitrous ammoniacal salt may be made, as the vitriolic, by three methods:

1. By combining to the point of saturation nitrous acid with volatile alkali.
2. By decomposing sal ammoniac by means of nitrous acid.
3. By decomposing nitrous salts with earthy or metallic bases, by means of volatile alkali. See **ALKALI (VOLATILE)**.

Nitrous ammoniacal salt has a very pungent taste; is soluble in water; capable of forming beautiful needle-like crystals, like those of ordinary nitre.

This salt has the singular property of detonating alone, when exposed to a certain degree of heat, and without the necessity of addition, as in ordinary nitre, of inflammable matter. It seems even to inflame with less heat than nitre mixed with inflammable matter does.

This property proceeds from the phlogiston or inflammable matter which enters as a principle into the composition of the volatile alkaline basis of this salt. This property also furnishes a decisive proof of the existence of this inflammable matter in volatile alkali.

This inflammability of nitrous ammoniacal salt renders it incapable of sublimation, like the other ammoniacal salts, as an explosion would certainly happen

mate, and the residuum of each preceding operation mixed with the sublimed salt, the whole matter became quite fixed in the fire, and would no longer rise from the bottom of the glass. *Newman*. 3. The degree of heat necessary to volatilize sal ammoniac is a little below that of ignition, nearly the same with which lead is melted. 4. *Pott* says, that a small quantity of sal ammoniac may be produced by distilling sea-salt with charcoal or with alum, or by distilling marine acid with Armenian bole. 5. The same author affirms, that the inflammability of sulphur is destroyed by subliming it with twice its quantity of sal ammoniac.

in the operation. Chemists do not seem to have examined particularly the properties of this salt; neither is it used in arts or in medicine. If this curious salt were to be more particularly examined, the operator would need the greatest circumspection to avoid explosions.

LIV. AMMONIACAL SALT (VEGETABLE). This name is given to all neutral salts formed by combinations of volatile alkali with vegetable acids. But these salts are hitherto little known, although they deserve to be examined. That saline combination formed by volatile alkali and vinegar is called *Spirit of Mindererus*.

LV. AMMONIACAL SALT (ANIMAL). As the fat of animals contains much acid, (See FAT) an ammoniacal salt might be formed by combining this acid with volatile alkali, which might be properly called animal ammoniacal salt. But this combination has not yet been made, or examined.

Lastly, the phosphoric salt, or native salt of urine, belongs to the class of ammoniacal salts; and as its acid appears to be peculiarly animal, it would also be in this sense a true animal ammoniacal salt. See SALT (FUSIBLE) of URINE.

LVI. AMMONIAC (FIXED): (r)

LVII. AMMONIAC (GUM). (s)

LVIII. AMETHYST. (t)

LIX. AMIANTHUS. (u)

LX. ANALYSIS. Chemists understand by the word analysis, the decomposition of a body, or the separation of the principles and constituent parts of a compound substance.

Chemistry furnishes several means for the decomposition of bodies. These means are all founded on the differences of the properties belonging to the different principles of which the body to be analysed is composed. Thus, for example, if a body be composed of several principles, some of which have a great, and others a moderate degree of volatility, and, lastly, others are fixed, its most volatile parts may be first separated, by a graduated heat, in distilling vessels, and then the parts which are next in volatility will pass over in distillation; and lastly, those parts which are fixed, and capable of resisting the action of fire, will remain at the bottom of the vessel. As this analysis cannot be made but by means of fire, it is called the *Analysis by fire*.

(r) FIXED AMMONIAC is a name given to the residuum formed by decomposing sal ammoniac with a calcareous earth. It is a salt composed of that earth and marine acid. (See SALT (MARINE) with BASIS of CALCAREOUS EARTH.

(s) GUM AMMONIAC is a gum resin, from an ounce of which six drams may be dissolved by spirit of wine, or six drams two scruples and a half may be dissolved by water. *Newman*.

(t) AMETHYST. This is a violet-colored, frequently yellowish or reddish, pellucid gem, the seventh in degree of hardness from diamonds, fusible by fire, which also destroys its color. It is found amongst quartz,

and is probably only a colored quartz crystal. This stone may be imitated by adding to a fritt of crystal-glass eight parts of magnesia and one part of saffre.

(u) AMIANTHUS is the lightest and softest of all stones. It consists of fibres parallel or interwove, so flexible, that cloth has been formed of them. By a strong heat it is whitened, hardened so as to be capable of striking fire with steel, and rendered brittle. It has generally been considered as unfusible by fire; but Mr. D'Arcet, in a Memoir of the French Academy for the year 1766, affirms, that by a violent and long continued fire it is fusible, and that it forms a black glass. This stone is insoluble by acids.



It is proper to observe, that this method of analysing does not succeed equally well upon all bodies, and that it is very imperfect upon some bodies, which being composed of principles of very different degrees of volatility, might seem well adapted to it. This particularly happens when the principles of substances analysed by this method have a great adhesion with each other; because in this case a volatile principle drags along with it a portion of the fixed principle, which would never have been raised by the degree of heat employed without this adhesion, and as it were, participation of the volatility of the former to the latter. Frequently, therefore, the principles obtained by this method of analysis are in part still united with each other, and are far from the proper degree of purity. In this case it is necessary to have recourse to new distillations, rectifications, and purifications, to obtain them sufficiently pure and separated from each other. This inconvenience particularly attends the analyses by fire of most animal and vegetable substances, in which analyses very volatile acids and alkalis are often procured, still united with much superfluous heavy oil. The best method of avoiding this inconvenience, or at least of diminishing it as much as possible, is to manage very carefully the fire; for it is evident that a too strong fire would readily confound all the principles of the substance to be analysed.

A second no less important remark concerning the analysis by fire, is, that by this method the *proximate principles* of very compound bodies, such as most vegetables, cannot be obtained; because these proximate principles being themselves very compound, and of a delicate mixture, cannot, for the most part, support the action of fire without a total or partial decomposition; or, at least, without receiving such considerable alterations that they can no longer be known. This inconvenience chiefly attends those proximate principles which are not possessed of great volatility, as we may see from the example of mild and fat oils, of gunny, resinous, saponaceous, and extractive parts of vegetables. These principles cannot ever be procured by distillation such as they were in the plant.

These inconveniences have induced chemists, particularly the modern, to search for other methods of decomposing bodies, and separating their principles.

They have found one method which wonderfully supplies in many cases the defects of the analysis by fire.

This second method of decomposing bodies is founded on the different degrees of solubility in most menstrua, which the different principles possess. Thus when a body is compounded of several substances; one of which, for instance, is soluble only by spirit of wine, a second is soluble only by water, and a third is soluble only by ether, these substances may be very easily separated from each other, by submitting successively the compound body to the action of these menstrua, each of which dissolves that particular substance to which it has an affinity, and from which it may be afterwards easily separated. This method of analysis is excellent to separate without any sensible alteration the greatest part of the proximate principles of vegetables, and to obtain them as they exist in the plants. If, for instance, a vegetable matter contain gum, resin, and an oil or oily concretion not soluble in spirit of wine; we may first deprive it by water of its mucilaginous and gummy parts, which may afterwards be obtained in their natural state merely by evaporation of the water; then, by applying to this vegetable matter spirit of wine, we may extract its resinous parts; and lastly, we may

may, by treating it with ether, separate its oily part, which could not be dissolved in the water or the spirit of wine. It is afterwards easy to obtain the substances dissolved by the ether and spirit of wine, pure and free from their menstrua, either by evaporation, or by addition of much water, which separates the oily and resinous parts. See SPIRIT of WINE, and ETHER.

As this method of separating the principles of bodies is solely founded on the action of menstrua, this kind of analysis has been called ANALYSIS by MENSTRUUMS.

What has been said on this subject is sufficient to make its great utility appear. We may add, that in some cases this is the only analysis which can be applied, and by which a perfect and complete separation can be effected. If, for example, the body to be analysed consists of two substances which equally resist the action of fire, as gold and silver, it is evident that these two substances cannot be separated from each other but by means of a menstruum which can only dissolve one of them. Thus, by exposing a mass composed of gold and silver to aqua regia, which dissolves the gold only, or to nitrous acid, which dissolves only the silver, the separation of these two metals may be effected. The operation called *Parting* ought then to be considered as the true analysis by menstrua. See PARTING.

We may say the same of all decompositions and precipitations which are made in numberless chemical operations by intermediate substances, either by the humid method, or by the dry, in different fusions. In all these cases, the intermediate substance employed effects the precipitation or separation of the body intended to be separated, by really dissolving another body to which the former was united. Thus the analysis by menstrua is at least of as extensive utility as the analysis by fire, since it takes place in almost all the operations of chemistry.

It is true, that in many cases the analysis by menstrua, as well as that by fire, is incomplete. This inconvenience happens when there is in the compound body to be analysed some intermediate substance, by means of which the menstruum is rendered capable of acting upon some of the principles, which it ought not to do, in order to have a complete and perfect separation. But these inconveniences may be prevented or repaired.

Frequently it is necessary, in order to make a perfect analysis of bodies, to unite these two methods by fire and by menstrua: the one may be made to assist the other; and from these combined means a decomposition results much more perfect, and more accurate, than could have been obtained by either of them separately. If, for instance, we intended to separate from spirit of wine superabundant quantities of oil and water which are generally united with it, we ought, instead of distilling it alone, to mix with it some fixed alkali, or very dry earthy matter, and then to proceed to the distillation: these alkaline or earthy substances acting upon the oil and water will retain and fix them; by which means the spirit of wine is allowed to rise much purer in distillation.

We shall say nothing more here upon analysis in general. This subject is so extensive, that to make particular applications of it, we should be obliged to consider all the objects in chemistry. Those who know the use of general principles will easily apply these to particular operations; and longer details would be fatiguing and useless to others. It is nevertheless proper to mention the general

neral articles which are related to this. See DECOMPOSITION, DISTILLATION, SUBLIMATION, PRECIPITATION, EXTRACTION, SOLUTION.

LXI. ANGELICA. (*w*)

LXII. ANIMAL. (*x*)

LXIII. ANIME. (*y*)

LXIV. ANISE. (*z*)

LXV. ANNOTTO. (*a*)

LXVI. ANTIMONY. Antimony is a mineral of a metallic, shining, leaden color, the masses of which have no determinate figure, but are composed of long, brittle, parallel needles. It is composed of a semimetallic substance called its *regulus*, united with sulphur, as most metallic substances are in their mineral state.

There are two kinds of antimony, namely, that which is called *native* or *mineral*, and is in the same state as when it is dug out of the earth; and *fused antimony*, so named, because it has been actually fused in order to separate it from adhering stones and earths. This operation, which ought rather to be called liquation than fusion, considering these words in their metallurgic sense, is made in great perfection upon the grounds whence antimony is dug. The process is very simple and easy. It consists in placing the mineral in earthen pots, pierced in their bottoms with small holes. These pots are placed in a furnace, where they receive the necessary heat for the fusion of the antimony. As it is very fusible, (for it melts before it is red) this degree of heat is much less than is necessary for the fusion of the earthy and stony matters mixed with it. The antimony thus melted runs through the holes at the bottom of the pots, and is received in other pots placed below, and defended from the heat as much as is possible. The antimony is allowed to cool and fix in these receivers, from which it therefore takes its form of cakes, in which it is sold. The countries which furnish most antimony are Hungary and Auvergne, whence the names *Hungarian antimony*, and *Auvergne antimony*. Antimony is also found in other countries, and in different forms; upon which subject consult the article ORE of ANTIMONY.

(*w*) ANGELICA. The root of this plant contains an essential oil, and a resinous matter. *Neuman*.

(*x*) ANIMAL KINGDOM. See KINGDOM.

(*y*) ANIME, according to *Neuman*, is a resin totally soluble in spirit of wine. It is called improperly *gum anime*. Other authors mention two substances to which this name is given, one of which is brought from India, and is resinous: the other is brought from Brazil, and is similar in appearance and insolubility in spirit of wine, or in water, to the substance called *gum copal*. All the anime which is to be found in shops of druggists is of this latter kind; and if it does not proceed from the same tree as *gum copal*, is scarcely distinguishable from it.

(*z*) ANISE. The outer thin skin of the seeds of this plant contains an essential oil,

and the kernel itself contains an inodorous, insipid, expressible oil. *Neuman*.

(*a*) ANNOTTO is a red mass extracted by infusion in water, and fermentation from the pellicles of the seeds of an American tree. To water this mass gives only a pale brownish-yellow color, and is very little soluble in that liquid. It readily dissolves in spirit of wine, and gives a bright orange color: hence it is useful as an ingredient in varnishes and lacquers. By alkaline salts it is rendered soluble in water, without any change produced upon its color. Wool and silk boiled in this solution acquire a deep, but not durable orange dye. Its color is not changed by alum or by acids; but is discharged by soaps, and is destroyed by exposure to air. It is said to be an antidote to the poisonous juice of manioc, or cassava.

As many remedies of great consequence are prepared from antimony, and as alchemists have supposed it essential to the *great work*, a very great number of chemical operations have been made upon this mineral, the results of which are distinguished by particular names. We shall here give a summary account of these operations, and shall make references for the particular details and explanations.

The metallic part of antimony is disengaged from its sulphur by several methods. The first and simplest is torrefaction, commonly called *Calcination of Antimony*. It consists in exposing crude antimony, grossly powdered, in a flat and shallow earthen vessel, to the action of a moderate fire, taking care to stir it constantly. During this calcination, the sulphur, being less fixed than the metalline part, is gradually evaporated. The calcination is continued till no more sulphureous vapors rise. What remains after the calcination is the metallic part of the antimony separated from the mineral sulphur, and even deprived of part of its own inflammable principle. This substance is much more fixed and less fusible than antimony, because in general metallic earths are so much more fixed and less fusible as they are deprived of more of their inflammable principle. It is called *Calx of Antimony*. It is of a grey ash color. When taken internally it is violently emetic and purgative, which antimony is not, because its metallic earth is enveloped by sulphur, and thereby deprived of most of its properties.

Calx of antimony, exposed to a great heat in a crucible, melts, and appears when cold a hard, compact, brittle, shining mass. This melted matter is sometimes transparent, and of a more or less deep hyacinthine color. It is then called *Glass of Antimony*, because it has the appearance and properties of a vitrified substance.

Sometimes calx of antimony, when fused and cooled, becomes an opaque brown mass. It is then called *Liver of Antimony*.

These differences proceed from the greater or less quantity of inflammable principle which remains united with the metallic earth of the antimony. They consequently depend on the length and accuracy of the calcination.

When this calcination has been slight, and much inflammable matter remains united with the earth of antimony, then the calx produced is capable of melting with less heat, and the result is liver of antimony, which ought to be considered as an intermediate matter between the vitrified and metallic states.

If the calcination has been more complete, the calx is of more difficult fusion, and the result from it is a vitrified substance.

Lastly, if the calcination has been as perfect as is possible, the remaining calx is still more refractory, and is even incapable of fusion and vitrification.

The calx, the liver, and the glass of antimony, are violently emetic. The phenomena which they shew when treated with chemical agents, are so much more similar to those exhibited by the regulus of antimony, as they approach more to the reguline state, that is to say, as they are more perfectly deprived of mineral sulphur, and less deprived of their inflammable principle.

These three preparations of antimony being treated in close vessels, and fused with matters capable of furnishing phlogiston, such as the black flux, are reduced not into antimony as they were originally, but into a semi-metallic, hard, brittle

brittle substance, of a dull white color, and composed of shining facets. This substance is called *Regulus of Antimony*. The cause of this change is, that by calcination this mineral is deprived of all the sulphur which is found united with its semi-metallic or reguline substance, and that this sulphur is not restored to it in the reduction above-mentioned. If then it be intended to restore the properties of antimony to its calx, liver, glass, or regulus, it ought to be combined by fusion not only with phlogiston, but also with a proper quantity of mineral sulphur.

Antimony may be disengaged from its sulphur, and at the same time reduced either into regulus, liver, or white calx entirely deprived of its phlogiston, by several other processes, much shorter and more expeditious than calcination, which is always very long.

If a mixture of four parts of crude antimony pulverised, three parts of tartar, and one part and a half of nitre, be projected at different times into a large red-hot crucible, and surrounded with burning coals; and when the detonation is finished, the fire raised so as the matter shall be fused; then upon breaking the crucible when cool, a mass is found consisting of two distinct substances, and which may be separated from each other by the stroke of a hammer. The lower substance is the reguline metallic part, and is called *Regulus of Antimony*. The substance lying above this is called *Scoria of the Regulus of Antimony*. This scoria is alkaline and acrid: it attracts the moisture of the air, and is composed, 1. Of the alkalis of the nitre and of the tartar alkali'd by each other in the operation; 2. Of a portion of the sulphur of the antimony, which during the operation united with the alkali and formed a liver of sulphur; 3. A portion of reguline substance of antimony dissolved by this liver of sulphur; 4. Lastly, some vitriolated tartar which was formed by a part of the acid of the sulphur combining during the detonation with the fixed alkali.

From the solution of the scoria of the regulus of antimony in water, a yellow reddish matter is deposited in a certain time, which is nothing else than a part of the sulphur and of the regulus of antimony which quit the alkali without separating from each other; consequently it is a kind of *Kermes*. When the solution of this scoria is saturated with any acid, a pretty large quantity of reddish matter is precipitated, which is composed, like the former, of sulphur and reguline parts. This matter is called **SULPHUR (GOLDEN) of ANTIMONY**, which see.

These two precipitates, and particularly the latter, are very emetic, although in them the reguline part is, as in antimony, which has no emetic quality, united with a large portion of sulphur. The true reason of this difference is, that in crude antimony the sulphur is much more intimately and strongly united to the semi-metallic part than it is in the golden sulphur.

Most metals, as iron, copper, tin, lead, and silver, have a greater affinity to sulphur than the regulus of antimony has. Hence this regulus may be precipitated in fusion, and its sulphur may be separated by means of these metals. The regulus thus obtained is called the *Regulus of the Metals*. The name of the particular metal employed to make this precipitation is added. Thus it is called, the *Regulus of Tin*, the *Regulus of Copper*, the *Martial Regulus*, accord-

ing to the metal used in the operation. Iron is most frequently employed to make this regulus, because of all metals it has the greatest affinity to sulphur, and for that reason separates most easily and perfectly the reguline part. See *REGULUS of ANTIMONY (MARTIAL)*.

If instead of detonating antimony with a sufficient proportion of nitre to obtain the regulus, equal parts of these two substances are employed; then, after the detonation, no regulus will be found at the bottom of the crucible, but a brown, opaque, brittle mass, of no metallic appearance; in a word, similar to that mass which is obtained by melting the calx of antimony alone, when too little dephlogisticated to be capable of vitrification. This mass is, properly speaking, the substance called *Liver of Antimony*, from its color, which somewhat resembles that of the liver of animals. By this process the liver is always made in small chemical laboratories. But it is said that in Holland, where many chemical operations are objects of manufacture, the liver of antimony is made by melting the calx of this mineral alone, sufficiently dephlogisticated. The liver of antimony prepared by either of these methods is a violent emetic and purgative. Several dispensaries require it to be employed in the preparation of *emetic tartar*. See *this word*. It is also used to purge horses.

When in this operation of liver of antimony by nitre, the matter has been well fused, it is observable that the mass found upon breaking the crucible is composed of two distinct substances. The liver of antimony, being the heavier of the two, is at the bottom; and above it lies a lighter and more saline matter, called the *scoria*, which may be separated by a hammer. This scoria is nearly of the same nature as that of the ordinary regulus. It is very acrid and alkaline, and contains vitriolated tartar, and liver of sulphur, by which some liver of antimony is kept dissolved. A golden sulphur of antimony may be also precipitated from this scoria by any acid.

When in the operation of the liver of antimony, the fusion has not been sufficient, or the mixture has been cooled too suddenly, then the scoria remains mixed with the liver of antimony, which it in some measure keeps dissolved.

Lastly, in detonating antimony with thrice its weight of nitre, after the operation, a mass perfectly white and void of color is found. This mass is a mixture of calx of antimony with certain saline matters. These are, 1. Nitre alkalisied by the phlogiston of the sulphur, and of the regulus of antimony; 2. Vitriolated tartar, proceeding from a portion of the acid of the sulphur, combined with the alkali of the nitre; 3. A portion of nitre undecomposed.

As to the calx of antimony obtained by this operation, it is perfectly white, because entirely deprived by nitre not only of all the mineral sulphur, but also of its own phlogiston.

This calx well washed, so as to be cleansed from the salts, is called *Diaphoretic Mineral*, *Diaphoretic Antimony*, and *White Calx of Antimony*. It is neither emetic nor purgative; for which reason a diaphoretic quality has been attributed to it.

The white calx of antimony is not soluble in acids. It is exceedingly fixed, and often refractory, being capable of sustaining the greatest violence of fire without vitrifying or melting. All these properties, so different from those of the

the regulus, the liver, and the glass of antimony, proceed from its being entirely divested of phlogiston by nitre.

The quantity of nitre employed in this operation is more than sufficient to dephlogistificate entirely all the earth of the antimony, since in the scoria is found some nitre undecomposed, because there was not phlogiston enough in the antimony for that purpose.

These phenomena of the calcination of antimony, which are conformable to those of all other metallic calcinations, prove in a satisfactory manner, that metallic matters owe their volatility, their fusibility, and their solubility in acids to their phlogiston.

The mass remaining in the crucible after the detonation, in the operation of diaphoretic antimony, and which consequently contains the calx of antimony and the salts resulting from the operation, receives aperitive, and even purgative qualities from the salts contained in it. It is called *Unwashed Diaphoretic*. It forms also the substance called the *Flux of Retrou*.

When the result from the detonation of diaphoretic antimony is washed, in order to cleanse it from the salts, the water dissolves not only the saline matters, but also the finest part of the calx of antimony adhering to these salts. This matter separates and precipitates in form of a very white and fine powder; for which reason it has been called *Pearl-Matter*. It has also been named the *Ceruss of Antimony*, and very improperly the *Fixed Sulphur of Antimony*. For it is evident from the nature of the operation, that no sulphur can remain in it, nor even any inflammable matter. The pearl matter also gives no marks of sulphur contained, and has absolutely the same properties as diaphoretic antimony; and if it differs in any thing, it is in being more perfectly calcined.

The white calx of antimony and the pearl-matter may be reduced into regulus by fusion in close vessels, with a reducing flux, as black flux, but only in part, and with considerable loss.

In all these operations, where antimony is exposed to a fusing heat, a considerable quantity of volatile matter rises in smoke, and adheres in form of a meal or fine powder to any cold body it meets. This is called *Flowers of Antimony*, which are nothing else than the semi-metallic part of the antimony, more or less deprived of the sulphur and phlogiston; but never entirely of the latter: for which reason, they are violently emetic.

In the chemical operations for procuring these flowers, only antimony itself or its regulus are employed. For this purpose a convenient apparatus and vessels are used. See *FLOWERS of ANTIMONY*, and *FLOWERS of REGULUS of ANTIMONY*.

When crude antimony is boiled in a lixivium of fixed alkali, a liver of sulphur is formed from the combination of this alkali with the sulphur of the antimony, by which the metalline part of the antimony is dissolved. But the alkali, by its being dissolved in water, having but a slight union with the sulphur, this antimoniated liver of sulphur cannot be kept suspended in the water, when the heat of that fluid is less, or much less than is sufficient to make it boil. Hence when the liquor cools, it becomes turbid; and a brick-colored sediment falls down, which has been called *Kermes Mineral*. This precipitate drags down along with it, according to a general rule of all precipi-

rates. a portion of the alkali by which it was kept dissolved. But this portion of alkali is very small. For this reason also the kermes cannot be kept dissolved but in very hot water. Hence it appears that kermes is nothing but an antimoniated liver of sulphur, containing the smallest possible quantity of alkali, or a superabundant quantity of sulphur and regulus of antimony.

Kermes may also be made by fusion, that is, by melting in a crucible dry alkaline salt and crude antimony, and then dissolving the combination in boiling water. The same phenomena appear, as in the preceding operation, and for the same reasons.

Kermes is a preparation of great utility and importance in medicine. *See the details, the preparation of Kermes, and the theory of it more extensively, as well as its medicinal virtues, at the article KERMES MINERAL.*

Acids difficultly dissolve regulus of antimony. To dissolve it by the vitriolic acid, the same process must be used as in the solution of mercury by this acid for the preparation of turbith mineral: that is, to employ a very concentrated acid, and to distill in close vessels. The same phenomena also occur in this operation as in that for turbith mineral: a very suffocating sulphureous acid rises; and as Mr. Geoffroy observes, a true sulphur sublimes, and adheres to the neck of the retort: a white saline tumefied mass remains in the vessel. When the vessels are unluted, a white fume issues like the smoking spirit of Libavius. These phenomena of the production of volatile sulphureous acid, and of concrete sulphur, are evidently effects of the combination of the vitriolic acid with the phlogiston of the regulus of antimony.

The nitrous acid does, properly speaking, only corrode and dephlogisticate the regulus of antimony, which it converts into a white calx. It dissolves a little better this reguline part, when it is applied to the antimony itself. This solution, as Mr. Geoffroy observes, acquires a blueish greenish color. When only a sufficient quantity of acid is employed, it may be seen to insert itself betwixt the stræ of the antimony, and there form small crystals.

Marine acid does not sensibly act upon antimony nor its regulus. It only detaches from the antimony, in lumps, some light and sulphureous flocks.

Aqua regia most directly and completely dissolves regulus of antimony. For this operation, it is proper to employ an aqua regia composed of four parts of spirit of nitre, and one part of spirit of salt. This menstruum is digested in a sand-bath with a gentle heat upon bits of regulus of antimony, which are added successively, so that one shall not be added till the former are dissolved. By means of this management, directed by Mr. Geoffroy in the Memoirs of the Academy of Sciences, aqua regia can dissolve about a sixteenth part of its weight of regulus of antimony. This solution has a beautiful golden color, which disappears by the evaporation of white fumes continually rising from it.

The aqua regia above described is also very proper to dissolve the reguline part of crude antimony, and the solution even succeeds better in this way. This is applicable to all the solvents of the regulus of antimony.

The combination of marine acid with regulus of antimony, which succeeds so ill by applying this acid directly to the semi-metal, may be much better made



made by employing a marine acid previously combined with mercury in corrosive sublimate.

When regulus of antimony or powdered crude antimony is mixed with corrosive sublimate, and this mixture distilled, the marine acid, having a stronger affinity with regulus of antimony than with mercury, quits the latter metallic substance to unite with the former; and from this a combination results which passes in distillation, and has a butyraceous appearance. It is a very corrosive metallic salt, and is called the *Butter of Antimony*.

When the regulus is employed to make the butter of antimony, the mercury is separated from the acid of the corrosive sublimate, and passes over in its metallic and fluid state towards the end of the operation, and when the fire is encreased.

But if antimony has been employed to make this butter, a cinnabar may be sublimed, by increasing the fire after the butter of antimony has passed over in distillation. This cinnabar results from the union of the sulphur of the antimony with the mercury, and is called *Cinnabar of Antimony*. See BUTTER and CINNABAR of ANTIMONY.

Butter of antimony is then the result of a combination of the metallic part of antimony with marine acid in its highest degree of concentration, and is therefore a powerful caustic. It may be rendered liquid by a small quantity of water; but if diluted with much water, then the greatest part of the regulus separates from the menstruum, and precipitates in the state of a white powder, which has been called *Powder of Algaroth*, and *Mercury of Life*. See these words.

The powder of algaroth is a very violent emetic. Mr. Beaumé has ascertained, by very accurate experiments, that when it is sufficiently washed it does not retain a particle of marine acid.

The liquor in which the powder of algaroth is precipitated contains all the marine acid of the butter of antimony, with a portion of the reguline part, which may be separated from it by precipitation with an alkali. This liquor has been named *Philosophical Spirit of Vitriol*; which name is improper, since it contains no vitriolic acid.

Nitrous acid poured upon butter of antimony dissolves it easily, and even violently. When this solution has been made gradually and cautiously, a transparent solution is obtained, impregnated with much regulus of antimony.

As in this operation the added nitrous acid forms with the marine acid, already united with the regulus in the butter of antimony, an aqua regia; and as aqua regia is the best solvent of this semi-metallic substance, a new solution takes place by the addition of this nitrous acid, entirely similar, as to its concomitant phenomena, to the solutions of metals by this acid, not previously dissolved by any other. This new solution is even so impetuous, that when the quantity of matter is considerable, it is apt to be thrown violently out of the containing vessels.

Butter of antimony is entirely changed by its union with nitrous acid. This acid, as is usual, seizes upon the inflammable part of the regulus of antimony which the marine had left unchanged: it diminishes the adhesion of the marine acid with the regulus. Hence it happens that this new combination of regulus  
of

of antimony with the acids of aqua regia, when dried and calcined, no longer possesses the volatility of the butter of antimony. Instead then of subliming or passing in distillation without decomposition, as the butter does, the new compound resists the action of fire, is not decomposed, lets its acids escape, and remains in the state of a white powder.

If fresh nitrous acid be twice poured upon this white powder, and each time the matter evaporated and calcined, the regulus of antimony is then reduced to a white earthy substance, indissoluble in the nitrous acid, entirely fixed and unfusible, and possessed of no emetic or purgative qualities. This preparation has been called *Bezoar mineral*. See this word.

This operation is one of those which proves most sensibly the power of the nitrous acid to calcine metallic substances, by depriving them of their phlogiston. It also proves that it is chiefly by means of this phlogiston that the nitrous acid dissolves these substances, since it cannot dissolve bezoar mineral, diaphoretic antimony, nor any other similarly dephlogisticated metallic substances.

LXVII. **A N N E A L.** Annealing consists in making metals red-hot which have become hard and stiff by frequent percussion, or by a strong compression, in order to restore their former malleability and tractability. All metals have the singular property of becoming more or less hard, untractable, and unmalleable, after they have been struck some time with a hammer. It seems as if something happened to them similar to the effect produced by the tempering of steel. Metals thus affected become more elastic than before, but, at the same time, more brittle. They are more sensibly affected in this manner in proportion as they are naturally harder. Copper is so much affected, and even gold and silver, by hammering, that they soon cease to be malleable, and are apt to split and crack, instead of being extended, under the hammer. This labor therefore must be often interrupted, to soften and restore malleability to metals. This is effected by making them red-hot, which the workmen call *annealing*. Thus heat produces the same effect on metals in the state described, as it does upon tempered steel: for if the hardest tempered steel be made red-hot, and cooled slowly, it becomes as tractable and ductile as the softest iron.

There is also an annealing for works made of glass. It consists in placing them, while newly made and still hot, in an oven or furnace, where they very slowly cool. This annealing for bottles and other glass utensils is quite necessary to render them serviceable; for all glass which is cooled suddenly is liable to be broken, not only by the least change of heat and cold, but even by the slightest force.

LXVIII. **A P Y R O U S.** This word is applied to denote that property of some bodies, by which they resist the most violent fire without any sensible alteration. Apyrous bodies ought to be distinguished from those which are *refractory*. Refractory substances are those which cannot by violent heat be fused, whatever other alteration they may sustain. But a body, properly speaking, apyrous, can neither be fused by heat, nor can undergo any other change. Hence it follows, that all apyrous substances are also refractory; but that every refractory substance is not apyrous. Very pure calcareous stones, for instance, are refractory, because they never melt without addition of other substance: but they are not apyrous; because by fire their weight is considerably diminished, the adhesion of their integrant parts is destroyed, and all their essential properties are changed.

changed by their conversion into quicklime. On the contrary, a very clear and pure diamond is apyrus, because the strongest fire is incapable not only of melting it, but also of producing upon it any other sensible alteration; so that a diamond which has been a long time exposed to the most intense heat, is found to be the same in all respects as it was before.

Perhaps there is no body in nature essentially and rigorously apyrus. This too is very probable; but it is sufficient that there be bodies apyrus relatively to the degree of fire which art can produce, to entitle them to that name.

**LXIX. A Q U A - F O R T I S.** Aqua-fortis is a name given by artists and manufacturers to nitrous acid, from its dissolving power. As it is not the concentrated and smoking nitrous acid which is employed in the arts, it seems that the name aqua-fortis may be retained by that acid which has not these qualities.

Most artists who use nitrous acid, call the purer and stronger kind; which is also considerably dearer, by the name of *Spirit of Nitre*. For the properties of this acid; see **ACID (NITROUS)**; and for the distillation of it, see **SPRIT OF NITRE**.

In the manufacture of soap, the caustic alkaline lixivium is called also the *strong water*, or *soap-lee*, or *lixivium of soap-boilers*. See **LIXIVIUM**.

**LXX. A Q U A - R E G I A.** Aqua-regia is a mixture of the nitrous and marine acids. These two acids are mixed to obtain a menstruum capable of acting upon certain bodies which no pure acid can dissolve, or but imperfectly. particularly gold and platina cannot be dissolved in their aggregated state by any other acid than by aqua-regia. Tin and regulus of antimony are better and more easily dissolved by aqua-regia than by any other acid.

This menstruum may be made either by merely mixing the spirit of nitre with spirit of salt, or by dissolving in spirit of nitre a salt containing marine acid, and particularly sal ammoniac and common salt. Lastly, it may be well made by distilling nitrous acid from either of these salts; because nitrous acid, being capable of disengaging marine acid from these salts, does actually disengage it, either by simply dissolving them in nitrous acid, or by distillation.

The only difference betwixt the several sorts of aqua-regia, prepared in these different manners, is, that the aqua-regia made by merely dissolving sal ammoniac or common salt in nitrous acid contains ammoniacal or cubic nitre, and that these neutral salts do not exist in the aqua-regia made by mixture of the two acids, or by distillation.

The presence of these neutral salts in aqua-regia does not injure its dissolving powers. Thus, as the aqua-regia which contains them is the easiest prepared, and least expensive, it is more generally used than the others. But it is necessary to observe, that the ammoniacal nitre in the aqua-regia may occasion considerable differences in the nature of the precipitates made from solutions of metals in this menstruum, by separating from these precipitates any of those metallic substances which it is capable of dissolving, and also by a portion of it adhering to precipitates. For instance, gold precipitated by a fixed alkali from an aqua-regia made by mixing the pure nitrous and marine acids, does not fulminate; whereas it does fulminate when precipitated from an aqua-regia made by dissolving sal ammoniac in nitrous acid. See **PRECIPITATES**; and **GOLD (FULMINATING)**.

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The mixture of the nitrous and marine acids presents a very singular and remarkable phenomenon; which is, that the vapors of this mixture are more expansive and more difficult to be confined than the vapors of either of the acids before mixing. This proves a re-action of these acids upon each other. This phenomenon is very little sensible when the acids employed contain much superabundant water; but is more manifest in proportion as these are more concentrated. I have observed, that upon mixing moderately smoaking nitrous and marine acids, which had remained without occasioning any disturbance in their bottles, an aqua-regia has been formed infinitely more smoaking, and which has made the stopper fly out of the containing bottle, particularly in weather somewhat warm. Mr. Beaumé, when distilling a pretty strong nitrous acid upon sal ammoniac, observed, that the vapors which passed were so elastic, that notwithstanding every precaution that could be taken in such a case, it was impossible to continue the distillation.

As to the proportions of nitrous and marine acids, or of sal ammoniac, which ought to be employed for the preparation of aqua-regia, there are no established rules. Common aqua-regia is made by dissolving four ounces of sal ammoniac in sixteen ounces of nitrous acid. But these proportions ought to be varied according to the nature of the solutions intended.

To dissolve, for example, the greatest possible quantity of platina, the best proportion is equal parts of the two acids.

To dissolve the greatest quantity of regulus of antimony, the aqua-regia ought to be composed of four parts of nitrous acid to one of marine.

In general, the greater the proportion of marine acid, or of sal ammoniac, is in aqua-regia, the less are the imperfect metals, and particularly tin calcined and precipitated by it. An aqua-regia, composed of two parts of spirit of nitre and one part of spirit of salt or of sal ammoniac, makes a clear solution of nearly an equal weight of tin, without forming any precipitate: but for this purpose, the operation must be performed slowly, and heat must be avoided as much as possible. See GOLD, PLATINA, TIN, and REGULUS of ANTIMONY. (b)

LXXI. A Q U A - S E C U N D A. This is nothing else than aqua-fortis diluted with much pure water. It is employed in several arts to clean the surface of metals and of certain stones, and for some other purposes.

LXXII. A Q U A - V I T Æ. Aqua-vitæ is the spirituous part obtained by a first distillation from wine, or any other liquor which has undergone the vinous fermentation. It is properly speaking, ardent spirit, or spirit of wine.

To make the aqua-vitæ that is sold in commerce, wine is put in large copper alembics or stills, to which worms are fitted, and the distillation is so conducted

(b) Aqua-regia does not dissolve silver: but when the quantity of marine acid contained in the aqua-regia is very small, the acid of nitre does then dissolve silver, which is immediately afterwards attacked by the marine acid, with which it forms the metallic salt called *luna cornea*, and is precipitated. Aqua-regia dissolves a larger quantity of lead than marine acid. All the other metals it perfectly

dissolves. According to Gellert's table, the substances which aqua-regia dissolves are placed in the following order, beginning with those to which it most powerfully unites: Phlogiston, zinc, iron, regulus of cobalt, copper, tin, arsenic, bismuth, mercury, lead, regulus of antimony, gold. In this table copper is erroneously placed before tin, as the latter metal readily precipitates the former. that

that the liquor flows out of the beak of the still in a constant stream, and is continued till the liquor begins to be no longer inflammable.

It is evident that this distillation, being hastily and unartfully performed, can only furnish a very impure spirit of wine, mixed with several of the other principles of the wine employed. Thus aqua-vitæ contains much superabundant water, and much oil of wine, substances entirely foreign to what is properly called spirit of wine.

These heterogeneous matters contained in aqua vitæ prevent it from being employed in chemical operations. To purify it, and change it into spirit of wine, it must be again distilled and rectified. See SPIRIT of WINE.

### LXXIII. AQUILA ALBA. (c)

LXXIV. ARBOR DIANÆ. The arbor Dianæ is the result of a chemical operation by which particles of silver, previously dissolved in nitrous acid, are capable of arranging themselves in the form of a shrub. Chemists have called this *Arbor Diane*, from the silver which they also call Diana or the Moon. The following process given by Lemerî for making the arbor Dianæ succeeds well :

“ Take an ounce of fine silver, dissolve it in a sufficient quantity of spirit of nitre, very pure and moderately strong; mix this solution of silver in a matrass with about twenty ounces of distilled water; add to this mixture two ounces of mercury, and let the whole remain at rest. During a space of about forty days, a kind of silver tree will be formed upon the mercury, with branches resembling vegetable ramifications.”

As this process is very long, we shall here add another much shorter, taken from a memoir of Mr. Homberg, and quoted by Mr. Baron, in his edition of Lemerî's Chemistry.

“ Make an amalgam without heat, of four drams of filings of silver, or, still better, of silver-leaf, and of two drams of mercury (See AMALGAM); dissolve this amalgam in four ounces, or a sufficient quantity, of spirit of nitre pure and moderately strong; dilute this solution in about a pound and a half of distilled water; shake the mixture, and preserve it in a bottle with a glass stopper: when this preparation is to be used, an ounce of it is to be put into a phial together with about the size of a pea of an amalgam of gold or of silver, which ought to be soft as butter; and the whole is to remain at rest: soon afterwards, small filaments are to be seen issuing from the small amalgam, which quickly encrease, branch out on both sides, and take the form of shrubs.”

This experiment, which is generally considered merely as curious and amusing, is founded on many of the essential properties of the substances employed. As mercury has a stronger affinity than silver to nitrous acid, it obliges this metal to separate and precipitate. But in this precipitation there are two essential particulars: the first is the color of the silver precipitated, which on this occasion appears in its natural form and metallic brilliancy. The cause of this is, that it was precipitated by a metallic substance; for it appears, that in general this happens whenever one metal is precipitated by another metal; whereas

(c) *Aquila Alba* is a name given to sweet mercury. See MERCURY (SWEET).

metals precipitated by any other substance are always in form of calxes, or earthy precipitates, without any metallic appearance. See PRECIPITATION.

The second remark to be made on the precipitation of silver in this experiment is, the singular arrangement taken by the particles of silver on the surface of the mercury one after another, according as they are separated from the nitrous acid. We cannot but perceive in this phenomenon a very sensible effect of the attraction or affinity of the integrant parts of the same substance, or of two similar substances to each other. In fact, it can only proceed from this affinity which the particles of silver first separated from the nitrous acid have with the mercury, that they rather attach themselves to the surface of that metallic substance, than to any part of the vessel or of the liquor; and it also proceeds from this tendency which the particles of silver have to each other, that those which are afterwards separated from the nitrous acid adhere to the particles already attached to the mercury, and to each other, rather than to any other body.

As to the necessary conditions for this experiment of the arbor Dianæ, it has been already recommended to employ very pure silver, nitrous acid, and water, because the greatest part of the extraneous matters with which these substances are generally mixed, are capable of precipitating the silver, which in the present experiment ought not to be separated but by mercury. See SILVER, and PARTING.

In the second place, it is absolutely necessary to dilute in much water the solution of silver; 1. To avoid the formation of crystals of silver, which might take place if this solution was too concentrated, these being a crystallization of silver in a saline state, very different from the arbor Dianæ which is required. See CRYSTALS of SILVER. 2. Because if the solution of silver was concentrated, the particles of silver would be precipitated too fast, and in too great quantity; by which they would be prevented from applying themselves regularly to each other, and would be thrown down confusedly.

In the third place, it is necessary that the nitrous acid should be saturated with silver before it is diluted with water, otherwise the unsaturated part of the acid must first dissolve its proper quantity of silver or mercury, before the precipitation can take place, which would lengthen the experiment so much more, as the quantity of water with which the solution was diluted was greater.

LXXV. ARCANUM CORALLINUM: This is nothing else than *red precipitate*, on which spirit of wine has been two or three times burnt, with an intention of rendering it milder. See PRECIPITATE (RED).

LXXVI. ARCANUM DUPLICATUM. This Latin name, which signifies *the double secret*, is one of the most generally known salts. It is the salt composed of vitriolic acid united with vegetable fixed alkali, and therefore does not differ from the *Sal de duobus*, and *vitriolated tartar*. See TARTAR: (VITRIOLATED).

LXXVII. ARCHIL. (d)

(d) ARCHIL, ARCHILLA, ROCHELLA, or ORSELLA, is a white moss which grows in the Canary and Cape de Verd islands, and according to Linnæus, on the western coast of

England. From this plant is prepared by grinding and moistening with volatile alkali, a beautiful purple dye, which is not durable, but is chiefly used to give a bloom as it is called,

## LXXVIII. ARGENTUM MUSIVUM. (e)

## LXXIX. ARRACK. (f)

LXXX. ARSENIC. Arsenic, or *white arsenic*, is, properly speaking, nothing but the flowers or calx of regulus of arsenic.

This substance has singular properties, which render it the only one of its kind.

It is at once a metallic earth and a saline substance. It resembles all metallic calxes in its capacity of combining with phlogiston, and of being thereby changed into a true semimetal.

But it very essentially differs from all metallic calxes and earths.

1. In being constantly volatile; whereas all other calxes of metals, and even of the most volatile semimetals, are very fixed when deprived of phlogiston.

2. Metallic calxes, so far from being soluble in water, are even for the most part indissoluble in the strongest acids. White arsenic, on the contrary, is soluble, not only in all acids, but also in water itself, as saline matters are.

According to Mr. Brandt, (*Acta Eruditorum Upsal. de Semimetallis*, 1731) arsenic may be dissolved in fourteen or fifteen times its weight of water, by help of a boiling heat, and transparent yellow crystals may be obtained by evaporating this solution.

3. Metallic calxes, when perfectly calcined, (the calx of the regulus of antimony not excepted) are entirely free from smell, taste, or other action upon the human body. On the contrary, arsenic always preserves a strong alliaceous smell, and when put on the tongue, it excites an impression of acrimony and heat, which produces an involuntary spitting; when taken internally, or even when applied externally, it produces the most terrible and violent effects of a corrosive poison.

4. No kind of earth, nor even the metallic earths, can contract an union with metallic substances. Arsenic easily unites with all metals and semimetals, with the same degrees of affinity that the regulus of antimony does, that is to say, in the order following, according to Mr. Cramer: Iron, copper, tin, lead, silver, gold.

It is proper to observe, that arsenic renders all the metals with which it is united brittle. It renders gold of a greyish color in its broken surface, silver of a deep grey, and copper white. Tin becomes by mixture with arsenic much harder and more unfusible. Lead becomes very hard and very brittle, and it changes iron into a blackish mass. These observations are taken from Mr. Brandt's Memoir quoted above.

called, to other colors. By adding solution of tin to an infusion of archil in water, a durable scarlet dye is produced, as Mr. Heliot says. The color of archil may be extracted by water, by volatile spirits, or by spirit of wine. It loses its color in glass tubes hermetically sealed, and resumes it upon exposure to air. A solution of archil in water gives a permanent and deep stain of a purplish color to marble.

(e) ARGENTUM MUSIVUM or MOSAICUM is a mass consisting of silver-like flakes,

used for the coloring of plaster figures, and for other purposes, as a pigment. It consists of an amalgam of equal parts of tin, bismuth, and mercury. It is to be mixed with white of eggs, or spirit varnish, and then applied to the intended work, which is afterwards to be burnished.

(f) ARRACK is a vinous spirit obtained by distillation in the East-Indies, from rice or sugar, as is said, fermented with the juice of cocoa nuts.

5. The more metallic calxes are deprived of phlogiston, the more unfusible they are rendered. On the contrary, arsenic is always very fusible. Its volatility alone prevents its perfect fusion. It volatilizes, vitrifies, and scorifies all solid bodies, excepting gold, silver, and platina.

6. Earths and metallic calxes have no action upon nitre, which (as is observed under the article *Nitre*) can be decomposed only by phlogiston, by vitriolic acid, and by sedative salt. Arsenic decomposes nitre with the greatest facility, not by combining with and destroying its acid, as phlogiston does, but by disengaging it, and uniting in its place with the alkali, as the vitriolic acid and sedative salt do.

Stahl and Kunkel both knew this property which arsenic possesses of decomposing nitre, and of disengaging its acid.

Stahl directs how to prepare by means of arsenic a very volatile nitrous acid, extremely concentrated, of a penetrating fetid smell, and blue color, although its vapors are red. This color, according to Mr. Beaumé's observation, is caused by the water which must necessarily be put in the receiver to condense the vapors of this very strong and difficultly condensable acid.

Kunkel also directs to make an aqua-fortis similar to that of Stahl, but by a much clearer and simpler process, since he decomposes nitre by arsenic alone; whereas Stahl employs in his mixture a martial vitriol calcined till it becomes red, and does not use pure arsenic, but a combination of equal parts of arsenic with antimony and sulphur, a combination which the chemists have called *Pirmieson*, or *Lapis de tribus*.

These two chemists contented themselves with examining the properties of the spirit of nitre, which they procured by means of arsenic, and nobody had examined the residuum in the retort after distillation.

This matter, being worthy of attention, has been resumed by Mr. Macquer, who has particularly examined the decomposition of nitre in close vessels by arsenic, and the new kind of salt remaining in the retort after the distillation of the nitrous acid.

These researches, the detail of which has been given in two memoirs printed in the collection of the academy, discovered to him that arsenic, by combining with the basis of nitre, after having chased the acid from it, forms with this alkali a kind of salt perfectly neutral, which he has called *neutral arsenical salt*. See SALT (NEUTRAL ARSENICAL).

Another decomposition of nitre by arsenic was known by chemists, and consequently also another combination of arsenic with the basis of nitre, called by some chemists, *Arsenic fixed by Nitre*, or *Nitre fixed by Arsenic*; but this latter combination differs from the arsenical salt of Mr. Macquer in this, that it is not a neutral salt, and that it preserves, on the contrary, all the properties of an alkali. See NITRE FIXED BY ARSENIC.

Mr. Macquer has also made another combination of arsenic with deliquated fixed alkali. Mention is made of it also under the article Salt (*Neutral Arsenical*). There the differences are shown betwixt these two combinations, although formed of the same substances.

White arsenic, although very volatile, is partly fixed by the adhesion which it contracts with different sorts of earths, and even so far as to sustain a vitrifying heat. It facilitates the fusion of many refractory matters, hence it enters into the composition.



composition of several glasses, to which it gives much whiteness and cleanness, nearly in the same manner as borax and the sedative salt do: but it also has the same inconvenience, namely, that glass, in which a considerable portion of arsenic enters, is very quickly corroded by the air.

Dyers employ white arsenic in several of their operations; but the effects it produces are not yet well known, and require a particular examination. Arsenic and its regulus, being capable of combining with all metals, is employed for several metallic compositions; such, for instance, as *white copper*, and *white tombac*. See these words.

Arsenic is employed successfully for making, together with copper and tin, metallic compounds of a beautiful white color, and of a very dense and close texture, and consequently capable of receiving a fine polish, of reflecting well the rays of light, and of being formed into metallic mirrors.

From what has been said concerning the properties of arsenic, we may conjecture that this substance is a metallic earth of a particular nature, intimately combined with a saline and even acid principle, which has never been separated from it by any chemical trial, which accompanies it in its combination with phlogiston when it takes a metallic form, and which adheres to it when, by the burning of this phlogiston, it becomes again white arsenic.

Thus Becker, without having been acquainted with all the properties of white arsenic, gives an idea of it very analogous to this conjecture. He defines it in his *Subterranean Physics*, "a substance composed of the earth of sulphur which is in common salt," (by which he seems to mean the acid of sea-salt) "and of a metal joined to it." In another place, he calls it "a coagulated aqua-fortis." And as he imagined he could trace every where his mercurial earth, or at least something mercurial, he calls mercury a fluid arsenic. He considers mercury, and metals precipitated by marine acid, for instance, *luna cornea*, as different kinds of artificial arsenic.

Arsenic combines with sulphur, and forms with it a compound of a yellowish tinge, more or less red according to the quantity of sulphur with which it is united. It is of a beautiful yellow color when the sulphur is only a tenth part of the mixture, and is then called *yellow arsenic*; when the sulphur is a fifth part of the mixture, it is of a very beautiful red color, and it is then called *red arsenic*. The mixture of sulphur renders it a little more fixed and more fusible. Thus red arsenic may be melted, and by this means acquires transparency: it then resembles a ruby, and has therefore been called *Dur*, or *arsenical ruby*.

All these compounds of arsenic and sulphur are artificial. They are prepared by mixing and subliming these two substances together in the proportions above-mentioned, or, still better, in subliming together the sulphur and arsenic of minerals containing these two substances.

Natural compounds are also found, which are combinations of sulphur and of arsenic, nearly of the same color as the red and yellow artificial arsenics. They come from the East, from Persia, and Turkey. The yellow are called *orpiment*, *orpin*, and *yellow rizaral*; the red are called *sandarach*, *realgar*, or *red rizaral*.

Agricola, Mathioli, Schroder, seem to have confounded the red and yellow artificial arsenics with the native, and after them most chemists and naturalists have

have also confounded them; a confusion for which they have been reproached by Hoffman, chiefly because he was convinced that native orpiment and realgars are not poisonous, like the yellow and red artificial arsenics, from experiments which he had made on purpose.

On this subject we must remark, that, notwithstanding Hoffman's experiments, which were made only once or twice upon dogs, it would be very imprudent to give the native orpiment or realgars internally: particularly as all chemical trials show that they contain an arsenical principle; and that Hoffman himself agrees, that when they have been exposed to fire, they become very violent poisons.

Hoffman also remarks, that the ancient physicians did not scruple to give internally orpiment and realgar, and justifies them from the reproaches thrown upon them by moderns. But we must observe, that the ancients were unacquainted with white, red, and yellow arsenics, which have been well known only within these two hundred years; and that if they had known the effects of these poisons, and their resemblance to the native orpiments and realgars, they would probably have been less bold. Distrust is as commendable as boldness is blameable in those matters, the almost insensible differences of which may occasion the most troublesome accidents. For this reason, we cannot approve of the singular security with which so great a physician, as Hoffman was, endeavors to inspire a confidence for so suspicious drugs as native orpiment and realgar.

We do not however mean to say, that there is no essential difference betwixt native orpiment and yellow arsenic. It is even agreed that the arsenic contained in the orpiment is better united with the sulphur, and is besides in a less proportion: for one part of orpiment appears to be composed of a sparry stone and mica, from which it receives a foliated and shining form.

When arsenic is combined with sulphur, a part of the sulphur may be separated from it merely by sublimation, because it is more volatile. But some of the sulphur always remains united with the arsenic, from which it cannot be separated but by an intermediate substance.

Fixed alkali and mercury are two intermediatestances proper for this operation.

When fixed alkali is used, it must previously be deliquated or resolved into a liquid, and with this the sulphurated arsenic is to be made into a paste. This paste is to be sublimed in a proper vessel with a heat gradually raised. The arsenic then sublimes in white flowers. When too much alkali is added, less arsenic is obtained: because some of the arsenic is retained by the part of the alkali which is unsaturated with sulphur. A liver of sulphur is found at the bottom of the vessel after the operation.

When mercury is employed for this separation, it must be triturated and mixed with the sulphurated arsenic, and the mixture sublimed. First the arsenic rises, then cinnabar. All the metallic matters which have a stronger affinity than mercury to sulphur may seem capable of being employed for this purpose; but there are two objections.

1. They have also a considerable affinity with arsenic, and mercury has none.
2. Arsenic

2. Arsenic has the remarkable property of taking from all metallic matters, excepting gold, silver, and mercury, a part of their phlogiston; so that it would be sublimed half reguified.

In the operation by mercury, a part of the cinnabar frequently rises with the arsenic; which makes it necessary to sublime it a second time.

Arsenic is soluble in all acids, and with them forms combinations which have not yet been sufficiently examined. The vitriolic acid has the property of rendering it much more fixed than it naturally is: an effect which it also produces upon mercury.

If a mixture of arsenic and concentrated vitriolic acid be distilled together, a vitriolic acid is obtained, which, as Mr. Macquer observes, has sometimes the exact smell of marine acid. When this solution is distilled till no more acid rises, the retort is then almost red-hot, and no arsenic is sublimed; but it remains fused at the bottom of the retort; and when it is cold, it is found to be one heavy, compact mass, brittle and transparent as crystal-glass. This kind of arsenical glass exposed to the air soon loses its lustre from the moisture it attracts, which dissolves and partly deliquesces it. This deliquium is extremely acid.

Arsenic treated with phlogiston in a proper manner combines with it, and assumes all the properties of a very volatile semi-metal, of a white shining color, more or less upon the grey. This substance is called *Regulus of Arsenic*. See this word for the manner of making this regulus, and for its properties.

The arsenic sold in commerce is brought chiefly from the cobalt works in Saxony for making *Zaffer*, and *Smalt*. Cobalt contains much arsenic, which must be separated from it by a long torrefaction, and which would be lost but for a particular contrivance for the collecting in.

For this purpose, cobalt is roasted in a vaulted oven, to which is adjusted a long crooked chimney. The arsenic in vapors passes along this chimney, and is there collected; the arsenic which attaches itself to the coldest and most distant part of the chimney is in form of a white or grey powder, called *Flowers*, or *Meal of Arsenic*; whereas that part of the arsenic which adheres to the hottest part of the chimney, and is the most remote from the furnace, sustains there a kind of fusion by which it is reduced into compact, heavy, white masses resembling white enamel. These masses of white arsenic are almost always interrupted by yellow or greyish veins and strata. These colors proceed from a little sulphur or phlogiston with which this part of the arsenic is still united.

As arsenic is seldom obtained in the great works entirely free from sulphureous or phlogistical particles, if it be required perfectly pure in operations of chemistry or of arts, it must be again sublimed after mixing it with some intermediate substance capable of absorbing its inflammable parts, such as fixed alkali or absorbent earth.

Arsenic is a very violent corrosive poison: it produces always the most painful symptoms and fatal effects, whether it be taken internally or applied externally. It ought never to be employed medicinally, although some people, nor very intelligent, give small doses of it in obstinate intermittent fevers, which it effectually cures, but is always attended with bad consequences to the patients, such as phthisis, and other no less troublesome diseases.

Persons.

Persons poisoned by arsenic suffer acute pains in their bowels, violent vomitings, cold sweats, synopes, and convulsions, which are always followed by death, unless prevented by speedy remedies. The best antidotes to this poison are large quantities of diluting and softening drinks, as mucilages, oil, milk. Perhaps absorbent and alkaline matters would also produce good effects, from the property which arsenic has of combining with, and in some measure of being neutralized by, these substances.

When the bodies of persons killed by arsenic are examined, their stomachs and intestines are found covered with red, black, livid, inflamed and gangrenous spots. Frequently also arsenic is found there in substance, which may easily be distinguished by its alliaceous smell, when put on burning coals, or a red-hot iron.

Mr. Geoffry's table does not shew the affinities of arsenic. In Mr. Gellert's they are zinc, iron, copper, tin, lead, silver, gold, and regulus of antimony. (g)

LXXXI. ASA-FŒTIDA (b)

LXXXII. ASBESTUS. (i)

LXXXIII. ASHES. This name is generally applied to the substance remaining of bodies containing an inflammable matter, of which they have been deprived by burning, or calcination in open air. Thus workmen, without understanding chemistry, and induced merely by analogy or resemblance, apply

(g) *Neuman* relates that arsenic precipitated almost all metallic solutions, but most of them very slowly. Silver, iron, copper, tin, lead, mercury, bismuth, were precipitated from aqua fortis, and gold from aqua regia. Solutions of mercury corrosive sublimate, of copper in aqua regia, of zinc in aqua-fortis, and of regulus of antimony suffered no precipitation. Solutions in vitriolic acid of zinc and of iron were precipitated, of copper very little. Sugar of lead, and solutions of sulphur with quicklime or fixed alkali were precipitated. The same author further relates, that arsenic was not precipitated from its solution in vitriolic or nitrous acids by oil of tartar or by volatile alkali, but it was precipitated from marine acid by oil of tartar.

Arsenic is used for many purposes; by dyers, as an ingredient in compositions for dyestuffs and other fine reds; by goldsmiths, in enamelling; by makers of glass, for promoting the fusion of fritt, and the clearness and transparency of glass; by potters, for a white glazing; by essayers, in form of glass, for promoting the scorification of ores which contain tin and antimony, for the preparation of compound metals, and for whitening copper and brass. *Neuman* says,

that a beautiful metal like the finest steel may be made by melting cast iron with arsenic, glass, and a little tin; and that a metal resembling silver may be made from iron, tin, arsenic, and perhaps a little copper. Mr. Brandt (*Act. Upsal.* 1733) proposes to make a varnish for ships, of arsenic with pitch, sulphur, or rosin, to preserve the timber from rotting, and from worms.

(b) ASA-FŒTIDA is a gum-resin, from four ounces of which rectified spirit is capable of extracting two ounces six drams and a half of resinous extract; and water, one ounce three scruples and a half of gummy extract. Four ounces of asa-fetida, distilled either with water or with spirit, yielded above a dram of essential oil, in which its peculiar smell resides. *Neuman*.

(i) ASBESTUS is a grey, greenish or blackish stone, possessed of the same chemical properties as amianthus, and is therefore referable to the same class of earths. See AMIANTHUS. The chief differences between these two stones are, that asbestos is heavier than amianthus, and its fibres are more hard and brittle.

*Folii asbestus* is a name given to plumbeolum. See ALUM (Plumes)

the name of *ashes* to metallic earths thus calcined. Pewterers, for example, give the name *Tin-ashes*, to the earth of this metal which in fusion has been deprived of its phlogiston and metallic properties. If workmen had always applied names as properly as they have done this, they could not have been blamed. See COMBUSTION.

LXXXIV. **A S A H O L E.** The *asa-hole* is the lowest part of a furnace, and is intended to receive the ashes falling from the fire, and to give a passage to the air which is introduced into the furnace, to keep up the combustion. See FURNACE.

LXXXV. **ATHANOR.** Chemists have distinguished by this name a furnace so constructed that it can always maintain an equal heat, and which shall last a long time without addition of fresh fuel.

The body of the *athanor* has nothing in it particular, and is constructed like ordinary furnaces. But at one of its sides, or its middle, there is an upright hollow tower, which communicates with the fire-place by one or more sloping openings. This tower ought to have a lid which exactly closes its upper opening.

When the *athanor* is to be used, as much lighted coal is put in the fire-place as is judged necessary, and the tower is filled to the top with unlighted fuel. The tower is then to be exactly closed with its lid. As fast as the coal in the fire-place is consumed, that in the tower falls down and supplies its place. As the coal contained in the tower has no free communication with the external air, it cannot burn till it falls into the fire-place.

The *athanor* being much celebrated and used by ancient chemists, it has been particularly described by many authors, and was formerly found in all laboratories. At present this furnace is much less employed, and is even neglected. The reason of this is, that all the ancient chemists were in search of the art of making gold; and being excited by this powerful desire, and confidence of success, they spared no trouble nor expence to accomplish their design. They undertook with it hesitation, operations which required great length of time and unremitting labour. Wherein now, these alluring hopes having vanished, the cultivators of chemistry have no other view than to extend and perfect the theory of this essential part of natural philosophy. This motive, although undoubtedly much nobler than the former, seems however to be less powerful over most men. For now, all long and laborious operations whence chemistry might receive great advantages, are neglected, as being tiresome and disgusting. There is, in fact, a considerable difference betwixt the hope of explaining a philosophical phenomenon, and that of obtaining an ingot of gold capable of producing many others. Hence the instruments employed in long operations, and particularly the *athanor*, are now much neglected; and also because the fuel in the tower is apt to stick there or fall down at once in too great quantity. The *Lamp-furnace*, which is a true *athanor*, may be successfully employed in operations which do not require much heat. See FURNACE (LAMP). (k)

LXXXVI. **AURUM MOSAICUM.** (l)

LXXXVII. **AZURE.** The word *azure*, which at present signifies in general a fine blue color, was formerly appropriated to *Lapis Lazuli*, called

*azure-stone*, and to the blue prepared from it. But since a blue has been extracted from cobalt, custom has applied to it the name of azure, although it differs considerably from the former, and is incapable of being used for the same purposes, and particularly for painting in oil. The former at present is called *Lapis Lazuli*, or only *lapis*, and the blue prepared from it for painting in oil, is called *Ultramarine*.

The name *azure* is generally applied to the blue made from the earth of cobalt and vitrifiable matters. This glass, which is called *Smalt* when in masses, is called azure only when it is reduced to a fine powder. Several kinds of azure are distinguished, according to its degrees of beauty, by the names of *Fine Azure*, *Powdered Azure*, and *Azure of Four Fires*. In general, the greater the intensity of color and the fineness of powder, the more beautiful and dear it is. Azure is employed to color starch; hence it has also been called *Starch-Blue*. It is used for painting with colors and for a blue enamel. See COBALT, SMALT, ZAFFRE. See also LAPIS LAZULI.

(1) AURUM MOSAICUM, or MUSIVUM, is a mass consisting of beautiful gold-colored flakes, prepared by amalgamating tin with half its quantity of mercury, mixing this amalgam when cold with half its quantity of sal ammoniac, and the same quantity of flowers of sulphur, and by exposing the whole mixture to fire in a matras, by

which means a sal ammoniac and cinnabar will be sublimed, and the residuum is the aurum mosaicum, or mosaic gold, weighing about  $\frac{1}{3}$  more than the tin originally employed. It is used as a pigment and for mixing with glass to imitate the spangles of lapis lazuli; for which latter purpose shining talk is also employed.

## B.

**LXXXVIII. BALANCE (HYDROSTATICAL).** The hydrostatical balance is an instrument by which the specific gravity of bodies is determined. For this purpose it is necessary to find how much any given weight of a body, whose specific gravity is required, loses or its absolute gravity when plunged into a fluid. All liquid substances are proper to determine specific gravities, because these gravities are only relative : but water has been generally employed for this purpose, because it is the most common liquid, and most constantly of a nearly uniform weight.

When a body is to be weighed in water, it is suspended to one of the arms of a balance, to the other arm of which is fixed an ordinary scale, and in this scale weights are to be put sufficient to maintain an equilibrium with the body suspended in air. The weight necessary for this purpose is to be observed and remembered. Then the same body still suspended at the arm of the balance, and counterpoised by the weights in the scale, is to be immersed in water, by which the equilibrium is destroyed, and the balance inclines to the side of the weights. The weights are therefore to be diminished till an equilibrium is restored with the body sunk entirely in water. The difference betwixt the weights of the same body weighed in air and in water, determines its specific gravity.

It is proper to observe upon this subject, 1. That water can determine the specific gravity of bodies only which are specifically heavier than itself. For it is certain, that if they were lighter than water they could not sink in it by their own weight, which is necessary for the experiment. In this case it is necessary to employ some liquid lighter than water, such as ethereal oils, spirit of wine, or ether.

2. It is proper to remark on the subject of the hydrostatical balance, that it can be employed conveniently for solid bodies only, because the fluids cannot be weighed in water but by means of some vessel which must be immersed along with them. But this vessel having its peculiar specific gravity would render a troublesome calculation necessary. Another method is then generally used to determine the specific gravity of liquids.

3. If the solid body, whose specific gravity is to be determined, be soluble in water, as, for instance, a lump of salt, water could not be employed for this experiment, because a quantity of it would be dissolved during the time of weighing ; by which an error would be occasioned so much greater as there was more

of the soluble body dissolved. In this case then it is necessary to use some other liquid which cannot dissolve the body, or else not to employ the hydrostatical balance, but the same method by which the specific gravity of liquids is discovered. *See GRAVITY, GRAVITY (ABSOLUTE), GRAVITY (SPECIFIC).*

**LXXXIX. BALLS (MARTIAL).** Martial Balls are a mixture of filings of iron and of cream of tartar formed into a solid consistence and form of a ball, which is used to impregnate water or other liquids with iron dissolved by the tartareous acid. To make these balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron vessel with some water. This mixture is to be stirred from time to time, till it becomes almost dry, and then it is to receive more water, and to be stirred as before. This treatment is to be continued till it acquires, when nearly dry, somewhat of the consistence and tenacity of pitched rosin. Then it is to be rolled up into the form of a ball, which is generally kept tied up in a rag, and when intended to be used, it is to be infused in water, till it gives some color to that liquid.

The infusion of martial balls is tonic, vulnerary, discutient, and aperitive; and is employed both internally and externally. *See IRON.*

Iron being soluble in all acids, is attacked in this preparation by the tartareous acid, which reduces it to a kind of neutral salt not crystallizable. This salt would remain liquid, and would form a *soluble martial tartar*, called *Tartarified Tincture of Mars*. If proper proportions of filings of iron and cream of tartar be used, and treated long enough for an entire and complete combination, nothing would be obtained but a liquor or *magma*, which could not be preserved in a solid form, but would be continually moist. Therefore in the martial ball there is a good deal of the cream of tartar and filings of iron not combined together, by which its solidity is preserved.

Hence it follows that the infusion of the martial ball is entirely of the same nature as the tartarified tincture of Mars; and therefore these preparations may be substituted for each other. *See TINCTURE of MARS (TARTARISED).*

**XC. BALLS (MERCURIAL).** Mercurial balls are an amalgam of mercury and tin, sufficiently solid to be moulded, and to preserve a given form.

The method of making them is by adding mercury to melted tin, and pouring the fluid mass into a round and hollow mould.

These balls are employed to purify water, in which they are boiled; for which purpose travellers often carry some along with them.

**XCI. BALLOON.** This name is given to glass bottles, or receivers, which are generally round like hollow spheres, or like foot-balls, called in French, *Balons*, whence they are named.

In a laboratory there ought to be balloons of different sizes, capable of containing from a quart of water to fifteen or twenty pints. The large balloons are employed in distillations in great, being capable of containing much, and having necks wide enough to admit those of large retorts. For the contrary reasons, small balloons are employed when the little matter is to be distilled.

Large balloons are also necessary when the vapors discharged during the distillation are very elastic and difficult to be condensed; because such vapors would

not.



not find in small vessels sufficient space to circulate and condense; hence they would either burst the vessel, or if a vent was given them to prevent that accident, they would be entirely dissipated and lost. Notwithstanding the size of the balloons employed, so much air is disengaged during the distillation of certain hard bodies, vegetable and animal, such as wood, tartar, hardhorn, &c. and the vapors of certain acids, such as the smoking spirits of nitre and of sea-salt, are so elastic and expansible, that a small hole in the side of the balloon is necessary to give vent to those vapors when necessary. Afterwards this hole, which ought to be about half a line in diameter, is to be closed with a peg of wood, or some lute.

It is to be wished, that in the glass-houses where chemical vessels are made, it was the custom always to make such holes in the balloons; which might easily be done by a pointed instrument, while the glass is still hot and soft. Instead of this practice, chemists are themselves obliged to drill holes through the balloons with considerable difficulty and hazard of breaking. This operation is performed in the following manner.

The most convenient part for drilling this hole is nearer the neck than the bottom of the balloon, and for this purpose one of those bubbles which are always found in glass is chosen.

This bubble is first of all cut or broke by the pointed angle of a flint, and afterwards the hole is to be completed by turning this pointed flint always in the same place. Mr. Beaumé observes, that when an emery is once made by the flint, the hole may be better finished by a triangular drill with a strong hard tempered steel point, because the angular points of the flint are continually breaking, by which the operation is prolonged. (m)

For certain operations balloons with two necks placed opposite to each other are used. One of these ought to be large enough to receive the neck of the retort, and the other to enter the neck of a second balloon. These two joinings must be well luted together. See LUTING.

This apparatus is called *Enlarged Balloon*. Its use is to encrease the whole space of the receiver, because any number of them may be adjusted to each other, and as they communicate with each other, the capacity is so much larger as their number is greater. But good artists seldom use so troublesome an apparatus. The only one of these vessels which is generally used, is a small oblong balloon with two necks, which is to be luted to the retort and to the great balloon. It serves to remove this receiver from the body of the furnace, and to hinder it from being exposed to too great heat. This small balloon with two necks is called an *Adopter*. As this adopter is larger in its middle than at either extremity, it serves also to receive solid bodies, and to prevent them from passing with the liquids into the great balloon. It is chiefly in distillations of volatile concrete salts that the adopter serves for this last purpose. See DISTILLATION and RECEIVER.

(m) Such pointed balloons, receivers and retorts are commonly made in England glass-houses. But as chemists may have occasion so drill holes through glass vessels, we shall describe the operation, that this operation may be best performed with a copper drill and emery, as a convenient instrument occasions vibrations apt to break the glass.

XCI. **B A L S A M.** By balsams are meant oily, odoriferous, and aromatic matters, liquid, but somewhat thick, which flow spontaneously from certain trees, or from incisions made on purpose to obtain a larger quantity.

These balsams, which may more particularly be called *natural balsams*, to distinguish them from some compositions also called balsams, derive their liquidity and smell from a greater or less quantity of essential oil which they contain, and which may be extracted by distillation with the heat of boiling water. *See OILS (ESSENTIAL).*

Balsams may be even considered as true essential oils, which have lost some of their odoriferous principle, and of their finest and most volatile part. When they are deprived of their remaining part of volatile oil, their residuums exactly resemble those which remain after the rectification of essential oils. These residuums are true resins, from the analysis of which the same principles are obtained as from natural resins; and these last are nothing but balsams exhausted by time, or by the action of the air, and of the sun, of all their odoriferous and volatile parts.

There are several kinds of natural balsams. They do not essentially differ from each other, but only in the smell and degrees of consistence. The same kind of balsam also frequently differs with respect to the degrees of these two qualities.

The principal natural balsams are the *balsam of Adetta*, or the *white balsam*, which is the most rare and dear of all; the *balsams of Tolu* and of *Rosa in shells*, both which Mr. Beaumé considers as the same kind of balsam, with this difference, that the first is liquid, and the second is almost dry; the *balsam of Copahu*, or of *Copaiba*, vulgarly *Copini*; *liquid styrax*, or *storax*; and *turpentine*. *See for an example of the analysis and properties of all these balsams the word TURPENTINE.*

XCI. **B A L S A M of S U L P H U R.** The balsam of sulphur is a solution of sulphur in oil.

Sulphur, from the quantity of phlogiston it contains, is insoluble in water and aqueous liquors: but it is soluble in oils, which also contain much phlogiston.

All oils, either expressed or essential, can dissolve sulphur: to make this solution, the oil ought to be poured on the sulphur in a marmalade placed in a sand-bath, and sufficient heat applied to melt the sulphur, according to Mr. Beaumé's observation, who kept these two substances a very long time together in a less heat, without perceiving any sign of solution.

While the oil is dissolving the sulphur, it acquires a reddish or brown color, an acrid and disagreeable taste, and a strong fetid smell like that of the combination of oil with vitriolic acid.

As water can dissolve only a determinate quantity of some salts, and as this quantity is greater when the water is warm than when cold, so also oils can dissolve only a determinate quantity of sulphur, and this quantity is greater when heat is applied: hence it happens, that when an oil is saturated with sulphur, by a suitable heat; a part of the sulphur thus dissolved separates from the oil, when the solution cools, and congeals at the bottom of the vessel in a crystallized form, in the same manner as some salts do, which having been dissolved in boiling water, crystallize on the application of cold.

The

The portion of sulphur remaining dissolved in oil is in a singular state; the addition of its constituent parts, namely, the vitriolic acid and phlogiston, seems to be much diminished by the union they contract with the principles of the oil. Its vitriolic acid unites with the starchy part of this oil; and thus these two principles have no longer the necessary relation to each other for the formation of sulphur. See SULPHUR.

It is certain at least, that all these changes happen when the balsam of sulphur is distilled. This is proved by the analysis which Monberg made of this combination: for by distilling it with a very slow fire, he obtained a volatile sulphureous acid, a vitriolic acid more or less strong and sulphureous, some oil, partly fluid and partly thick, and a starchy residuum, but no sulphur. This is a proof that the sulphur was decomposed in the experiments; as all the same products are obtained from a combination of vitriolic acid with oil, when the oil is in too great quantity relatively to the acid.

The balsams of sulphur are named from the particular oils which enter into their composition. Thus if a balsam of sulphur be made with the essential oil of turpentine, it is called *recombined balsam of sulphur*; if it be made with the essential oil of sweetgum, it is called the *balsam of sulphur with oil of sweetgum*. These are the two most used. The balsam of sulphur made with oil of nuts is called *Kulland's balsam of sulphur*. See SULPHUR.

#### XCV. BASALTES (a)

XCV. BASALTES. BASE. Any body which is dissolved by another body, which it receives and loses, and with which it forms a compound, may be called the basis of that compound. Thus, for example, the bases of neutral salts are the alkaline, earthy, and metallic matters which are saturated by the several acids, and form with them these neutral salts. In this sense it is that these neutral salts are called *salts with earthy bases, salts with alkaline bases, salts with metallic bases*; also the appellations, *basis of alum, basis of nitre, basis of Glauber's salt, basis of vitriol*, &c. signify the *argillaceous earth*, which, with the vitriolic acid, forms alum; the *carbonaceous alkali*, which, with the nitrous acid, forms nitre; the *mineral alkali*, which, with the vitriolic acid, forms Glauber's salt; and the *metal*, which, with the vitriolic acid, forms a vitriol, because these substances are supposed to be fixed, inactive, and only yielding to the action of the acids, which they lose, and to which they give a body and consistence.

It is proper, for the convenience of chemical language, to retain these expressions: but these bases must not be considered as really inactive; for in every combination and solution the several bodies which unite are equally active, their action being reciprocal. They dissolve each other; so that it is as proper to say, as Mr. Gellert observes, that a metal or an earth dissolves an acid, as that an

(a) BASALTES is a heavy, hard stone, chiefly black or green, consisting of numerous crystals, the number of the faces of which is uncertain. It is called by English authors *basalt*, and by German authors *basaltstein*. Its specific gravity is so that it sinks in water or upwards in oil. It is considered by Wernerk as a species of the *crystalline horn* class. Cronstedt enumerates it among the *basalts*.

which he called *Garnet earth*. Basalts frequently contains iron, and consists either of particles of an indeterminate figure, or of a sperry, rounded, or fibrous texture. Black basalt is called *Lava*, and is used as a substitute to lime, the colors of metals. Basalts has a stony hardness, is unsoluble by acids, and is fusible by fire. See GARNET.

acid

acid dissolves a metal or an earth; although this latter mode of expression be more general. It is even probable that the dissolving power which the more weighty and fixed bodies have is really much stronger than that of bodies less weighty and fixed. This is certainly so if the tendency to unite be only an effect of the general attraction or gravitation of all particles of matter to each other. See COMBINATION and SOLUTION.

XCV. BATH. Chemists call several matters which they employ to transmit heat, *Baths*. The matters most frequently used for this purpose are water and sand.

When water is employed it is called *Balneum Mariæ*, or *water-bath*. The water-bath is much used, and is convenient for many operations.

As water, when exposed to fire in any vessel from which it can evaporate, does only receive a determinate degree of heat, which always remains the same, when once it has arrived to the boiling heat, it follows, that by the water-bath a degree of heat always equal may with certainty be transmitted. Further, this degree of heat being incapable of burning, or of communicating an empyreumatic quality to matters susceptible of it, the water-bath has also the advantage of not exposing substances to this inconvenience. The water-bath may likewise be employed successfully for all degrees of heat inferior to that of boiling water. See ALEMBIC, for the structure of the water-bath.

When vessels in which distillations and digestions are made, are placed in sand, then a *sand-bath* is formed. This intermediate substance is also very convenient to moderate the too great activity of the naked fire, and to transmit any degree of heat from the weakest to a red heat. As this bath is attended with less trouble, and requires less apparatus than the water-bath, it is much used in laboratories. For the sand-bath nothing is requisite but an earthen or iron vessel filled with fine sand. This vessel is fitted in to a furnace, and is capable of containing the cucurbits, retorts, matrasles, or other vessels containing the matter to be operated upon.

The only baths now generally used in chemistry are those mentioned, the water and sand-baths, because they are the most convenient, and are sufficient for all the operations which do not require a naked fire.

Ancient chemists, who had all a tincture, more or less, of alchemy, and who for that reason were much more careful and laborious in their operations, used many different baths, in order to apply precisely the required degree of heat. They used the vapor of water, ashes, dung, the substance remaining after the squeezing of grapes, and whatever they imagined most proper for their purposes: hence the names of *vapor-bath*, *ash-bath*, *dung-bath*, *bath of a horse's belly*, &c. But as we have said, an intelligent and experienced artist may very well perform all the chemical operations, which do not require a naked fire, by means of the water and sand-baths. See DISTILLATION and DIGESTION.

The word *bath* is also used in another sense to signify the fusion of metallic matters in certain operations: thus, for example, in refining or cupelling, the metals are said to be *in-bath*, when they are melted. When gold is purified by antimony, this semimetal melted is called by some chemists the *bath of gold*. Alchemists, who consider gold as the king of metals, call antimony, *the bath of the king only*, *balneum solius regis*; because, in fact, gold only can resist the action of antimony. See PURIFICATION of GOLD by ANTIMONY.

XCVI. BDELLIUM. (o)

XCVII. BEE-GLUE. (p)

XCVIII. BEER. Beer is a spirituous liquor made from any farinaceous grain, but generally from barley. It is, properly speaking, the wine of barley. The meals of any of these grains being extracted by a sufficient quantity of water, and remaining at rest in a degree of heat requisite for the spirituous fermentation, naturally undergo this fermentation, and are changed into a vinous liquor. But as all these matters render the water mucilaginous, fermentation proceeds slowly and imperfectly in these liquors. On the other side, if the quantity of farinaceous matter be so diminished that its extract or decoction may have a convenient degree of fluidity, this liquor will be impregnated with so small a quantity of fermentable matter, that the beer or wine of the grain will be too weak, and have too little taste.

These inconveniences are remedied by preliminary operations which the grain is made to undergo.

These preparations consist in steeping it in cold water that it may soak and swell to a certain degree, and in laying it in a heap with a suitable degree of heat, by means of which, and of the imbibed moisture, a germination begins, which is to be stopped by a quick drying, as soon as the bud shews itself. To accelerate this drying, and render it more complete, the grain is slightly roasted, by making it pass down an inclined canal sufficiently heated.

This germination, and this slight roasting, changes considerably the nature of the mucilaginous fermentable matter of the grain. The germination attenuates much, and in some measure totally destroys the viscosity of the mucilage; and it does this, when not carried too far, without depriving the grain of any of its disposition to ferment. On the contrary, it changes the grain into a saccharine substance, as may be perceived by mashing grains beginning to germinate. The slight roasting contributes also to attenuate the mucilaginous fermentable matter of the grain. When the grain is thus prepared, it is fit to be ground, and to impregnate water with much of its substance without forming a glue, or viscous mass. The grain thus prepared is called *malt*. This malt is then to be ground, and all its substance, which is fermentable and soluble in water, is to be extricated by means of hot water. This extract or infusion is sufficiently evaporated by boiling in caldrons; and some plant of an agreeable bitterness, such as hops, is at that time added, to heighten the taste of the beer, and to render it capable of being longer preserved. Lastly, this liquor is put into casks, and allowed to ferment; nature performs the rest of the work, and is only to be assisted by the other most favorable circumstances for the spirituous fermentation. See FERMENTATION (SPIRITUOUS).

XCIX. BEN. (q)

(o) BDELLIUM is a gum resin, from an ounce of which may be extracted by water six drams and two scruples, or by spirit two drams. *Acumen.*

(p) BEE-GLUE is a soft, unctuous, glutinous matter employed by bees to cement the combs to the hives, and to close up the cells. *Neuma.*

(q) BEN-NUTS yield, by expression, much oil, which, from its property of not becoming rancid, at least for years, is used as a menstruum for the extraction of the odoriferous part of flowers of jacinth, violets, roses, hyacinths, lilies of the valley, tuberoses, jonquils, clove-july flowers, and others, which, like these, yield little or no essential

C. BENJAMIN. *Benjamin*, or *Benzoin*, is a resin of an agreeable aromatic smell, from which an essential salt, or volatile, concrete, crystallized acid, called *flowers of Benjamin*, is obtained by sublimation. See FLOWERS of BENJAMIN. As to its other principles, it is similar to other resins. See RESIN.

CI. BERYL. (r)

CII. BEZOAR MINERAL. Bezoar mineral is the earth of the regulus of antimony deprived of all its phlogiston by the action of the nitrous acid and by calcination.

The ordinary process to make this preparation consists in dissolving butter of antimony in a sufficient quantity of nitrous acid, or till the phenomena of solution cease. If more nitrous acid be added than is necessary for the solution, no inconvenience follows, as we shall presently see.

When the solution of butter of antimony is made, it is to be evaporated to dryness in a glass or stone-ware vessel: more nitrous acid is then to be poured upon it; rather too much than too little; because an excess of this does no harm: this solution is to be evaporated, as at first, and the same operation is to be repeated a third time; after which the matter being dried, is to be calcined for half an hour, till, according to Lemery, a very slight acidity only remains.

This operation, which was invented for the preparation of a remedy, furnishes phenomena very worthy of attention, and fit to illustrate the essential properties of the nitrous and marine acids. The following remarks then are to be made on this subject: Aqua-regia being the most active menstruum of regulus of antimony; and spirit of nitre, in which the butter of antimony is dissolved, forming an aqua-regia with the marine acid contained in this butter; a new solution is made of the reguline part, which after this is no longer united with the marine acid only, but with the nitrous and marine acids jointly, that is, with aqua-regia. When this solution is not hurried too much, it is clear and limpid, and this is the best method of having the greatest possible quantity of regulus of antimony perfectly dissolved by aqua-regia.

As upon this occasion, the nitrous acid finds the integrant parts of the regulus of antimony separated from each other by the dissolution of the parts of the marine acid, and consequently the aggregation of the regulus of antimony broken, this nitrous acid seizes upon all the parts of the regulus with so much more facility and almost instantaneously: hence it happens that unless the nitrous acid be gradually added, and at long intervals, the solution is made so impetuously, that all the matter is apt to rise instantly over the containing vessel with effervescence, which happens in most solutions, and which proceeds from disengaged air. The

essential oil by distillation, but impart their fragrance to expressed oils. The method of impregnating oil of ben with the odor of flowers is this: Some fine carded cotton is dipped in the oil, and put in the bottom of a proper vessel. On this is spread a thick layer of fresh flowers, above which more cotton dipped in oil is placed; and thus alternately flowers and cotton are disposed, till the vessel (which may be made of tin, with a cover to be screwed on to it, or of porcelain) is full. By digestion during 24 hours in a

water-bath, the oil will receive the odor of the flowers.

(r) BERYL, or AQUA-MARINA, is a polygonous pellucid gem, the tenth from a diamond in hardness, of a sea-green color, and fusible by fire. This gem may be imitated by adding, at several different times, to twenty pounds of crystal glass, made without magnesia, and well purified from glass-gall, six ounces of calcined brass or copper, and a quarter of an ounce of prepared zaffre.

quantity

quantity of air in this solution is very great. Dr. Hales has ascertained that thirty-six cubic inches of air are disengaged from the solution of half a cubic inch of butter of antimony in as much nitrous acid: but this must vary according to the manner of making the solution. Is it even certain that it is air which is thus disengaged, and not some other substance reduced to elastic vapor?

However it be, the new combination of regulus of antimony with the acids of aqua-regia is very different from the butter of antimony. The presence of the nitrous acid produces an entire change. This metallic substance is no longer united with a single acid, incapable of depriving it of its phlogiston, and which, by its intimate union, communicates to the semimetal its volatility. The nitrous acid cannot unite with the regulus of antimony without depriving it of a large portion of its inflammable principle. The regulus thus half calcined can no longer have the same adhesion to the marine acid; therefore if this new combination be exposed to the action of fire, the marine acid, which now scarcely adheres to this altered metallic matter, far from raising it, as when it was combined with no other acid, does with great facility evaporate; and the nitrous acid, which adheres still less than the marine acid to this metallic earth, quits it still more easily, and continues to deprive it more and more of its inflammable principle.

The same effects ought to take place still more upon the new additions and evaporations of the nitrous acid; therefore, after all these operations, nothing remains but an earthy white matter, absolutely fixed, unfusible, and insoluble in acids, which has no longer any emetic or purgative qualities, nor any taste, if sufficiently calcined. It is, in short, a true calx of antimony, entirely similar to diaphoretic antimony, except that to this latter preparation a small portion of the earth of the alkaline basis of nitre adheres, which is not to be found in bezoar mineral: hence we ought to conclude, that nitrous acid produces the same effects upon the regulus of antimony by the humid, as it does by the dry way.

When bezoar mineral is prepared for the purposes of medicine, it is proper not to calcine it too much; otherwise it would probably have no virtue. When it is moderately calcined, as Lemery prescribes, it may have the sudorific virtue ascribed to it, from the small quantity of acid and perhaps of phlogiston adhering to it. It is this sudorific virtue, truly or falsely ascribed, which has occasioned the name of bezoar mineral, because the animal bezoar is considered also as a sudorific.

It is evident from what has been said concerning the nature of the bezoar mineral, and what passes during its preparation, that the marine acid contained in the butter of antimony is entirely lost, and not essential to the operation, since the nitrous acid alone is capable of depriving the regulus of antimony of all its phlogiston, and of reducing it to a white calx entirely similar to bezoar mineral. Instead then of employing butter of antimony, which requires a preliminary and expensive preparation, the nitrous acid may be directly poured upon the powdered regulus, and its action assisted by heat. This acid readily corrodes the semimetal, without dissolving it; because it deprives it of its phlogiston while it attacks it, and quickly reduces it to a white calx.

When this acid is carried off, and more acid poured on, and this repeated several times, till the matter is at last calcined, a white calx of antimony is obtained entirely similar to bezoar mineral.



### CHH. B I L E. (s)

CIV. B I S M U T H. Bismuth, called also *tin-glass*, and by some naturalists *marcesita officinarum*, is a semimetal somewhat similar to the regulus of antimony. It appears to be composed of cubes formed by the application of plates upon each other. Its color is less white than that of the regulus of antimony, and has a reddish tinge, particularly when it has been exposed to the air.

It is the heaviest of the semimetals, and loses in water about a ninth part of its weight.

It is also very fusible, and melts a long time before it is red-hot.

Bismuth is semi-volatile, like the other semimetals. When exposed to the fire, flowers rise from it; it is calcined; and converted into a litharge and glass nearly as lead is. It may even be employed, like that metal, to the purification of gold and silver by cupellation.

It easily combines with sulphur, and is thereby reduced into a striated mineral like antimony.

It amalgamates with mercury, and, according to Mr. Wallerius, it has the singular property of so attenuating tin, silver, and especially lead, when any of these metals are added to this amalgam, that a part of them passes along with the mercury through chamois leather. This sufficiently proves that this method of purifying mercury is insufficient. (*Wallerius's Mineralogy*).

Mr. Cramer, on the contrary, says that only lead, and not the other metals, can be so disposed by bismuth as to pass along with the mercury. He adds, that the lead must be previously united by fusion with the bismuth; and that if the amalgam be digested during some days, the bismuth is separated, and the lead is left attenuated with the mercury.

This semimetal is not equally soluble in the several acids.

The vitriolic acid does not, properly speaking, dissolve bismuth. If a part and a half of bismuth be mixed with one part of concentrated vitriolic acid, the whole distilled to dryness, and the residuum washed with water, the liquor drawn off is of a red yellow color, but from which nothing can be precipitated by alkalis: hence it may be suspected that the vitriolic acid attacks only the inflammable part of bismuth, and does not dissolve its metallic earth.

The nitrous acid dissolves bismuth very well.

The marine acid attacks and dissolves bismuth a little, but slowly and difficultly. Alkalis form a precipitate with marine acid in which bismuth has been digested a certain time.

This semimetal does not very sensibly detonate with nitre. It is, nevertheless, calcined by this salt, as all the imperfect metals and semimetals are.

Two parts of nitrous acid dissolve with heat and effervescence one part of bismuth. The solution is clear, limpid, and rose-colored. It coagulates into small crystals as soon as it cools.

(s) BILE of ANIMALS is an oily, viscid, saponaceous fluid, diffusible in water, and when thus diluted, more putrescent than other animal fluids. Impurified bile may, by heat, be first melted, and then decomposed, yielding by distillation an urinous spirit, a volatil fat, much empyreumatic

oil, and a residuum containing a considerable quantity of fixed alkali. Acids also decompose it, are thereby neutralized, and precipitate from it a resinous matter, not soluble in water, but partly soluble in spirit of wine.

This



This solution ought to be made gradually, to avoid too great commotion and effervescence.

Water alone being added to this solution, precipitates the bismuth. The precipitate is of a very beautiful white, and is commonly called *magistery of bismuth*, and by some artists *Spanish white*, being the same which is used as a paint for the skin.

To have this white very beautiful, an aqua-fortis must not be employed, which is adulterated by a mixture of vitriolic acid; for this latter acid gives it a greyish cast.

If the nitrous acid has dissolved but little bismuth, much more water is necessary to effect a precipitation.

This magistery ought to be well washed, to deprive it as much as possible of the adhering acid, and preserved in a well closed bottle; because this semimetal, when thus divided, has, like silver and lead, the property of easily combining with phlogiston in vapor, and of becoming black by that addition: hence the skin or women painted with this white may be rendered quite black by the phlogistic vapors which rise from putrefying matters, necessary-houses, sulphur, liver of sulphur, bruised garlic, &c.

Alkalis also added to the solution of bismuth occasion a white precipitate of this semimetal, but not so beautiful as when water only is used; because the purest alkalis contain some phlogiston, which gives more or less color to the precipitate.

Some authors recommend a solution of sea-salt in water for the making of this precipitate. But Mr. Pott, in his Dissertation on Bismuth, has shewn that the marine acid does not precipitate this semimetal, and separate it from the nitrous acid, as it does silver, lead, and mercury.

Thus, although bismuth resembles lead in many of its properties, as the younger Mr. Geoffroy has shewn in the Memoirs of the Academy, so that some chemists have called it the lead of the semimetals, it appears, that, besides want of ductility, it differs essentially from that metal in other respects.

Lémeri says, that if the solution of bismuth be used to write with as an ink, that the writing does not appear, but that it becomes very black, when moistened with the deliquated liquor of the scoria of regulus of antimony. This solution is therefore a sympathetic ink. The reason of this phenomenon is founded on what we have observed concerning the property which bismuth has, when much divided, of easily imbibing a superabundant quantity of phlogiston, and by that means of acquiring a black color.

The scoria of regulus of antimony is almost entirely liver of sulphur. The alkali of this liver precipitates the bismuth from the solution employed to write with; and the sulphur or phlogiston, disengaged from the liver, blackens the bismuth, which therefore becomes visible.

It is evident after this explanation, that it is needless to have recourse to the solution of scoria of regulus of antimony in this experiment; for it only acts as a liver of sulphur, and the portion of regulus of antimony contained in this scoria contributes nothing to the success: the liver of sulphur alone may therefore be as well employed.

Bismuth readily unites with all metallic matters, excepting, according to Mr. Gellert, zinc and arsenic; and all the alloys are rendered more fusible by bismuth.

mith. This chemist places the affinities of metallic matters with bismuth in the following order: iron, copper, tin, lead, silver, and gold. (1)

CV. BISTRE. (u)

CVI. BITTERN. (w)

CVII. BITUMEN. Bitumens are oily matters, of a strong smell, and of different consistences, which are found in many places within the earth.

There is only one liquid bitumen known: it is called *petroleum*, because it is an oil which actually flows from clefts in certain rocks, and it is gathered in wells dug in certain grounds and mountains. See PETROLEUM.

Solid bitumens are *Amber*, called also *Karubi*, or *yellow amber*; *Jet*; *Asphaltum*, or *bitumen of Judea*; and fossil or *pit-coal*.

All these bitumens, when distilled, furnish phlegm, an acid liquor frequently sulphureous, a thin oil like petroleum, a volatile acid and concrete salt, (of which amber gives the largest quantity) a black and thick oil, and lastly, a charry residuum, more or less earthy and copious, according to the nature of the particular bitumen analysed. Fossil coal furnishes the largest quantity of this residuum. From this analysis it appears, that bitumens are composed, like all other vegetable and animal concrete oily matters, of an oil and an acid. They differ in general from resins by their greater solidity; by their smell, which is stronger, and not like the aromatic smell of resins; by their insolubility in spirit of wine; by the volatile sulphureous acid; and finally, by the concrete acid obtained in their analysis.

The origin of bitumens is an interesting question, concerning which naturalists are not agreed; some imagining that they essentially belong to the mineral kingdom, and others that they proceed originally from vegetable substances. We

(1) 1. Bismuth, like iron, is said to *occupy, when fused, a less space than when solid*. 2. It is fusible with a heat of 460° of Fahrenheit's thermometer. 3. It greatly *increases the fusibility of some other metals*. Thus, an alloy consisting of equal parts of tin and bismuth is fusible with a heat of 280° of Fahrenheit's scale. 4. Equal parts of gold and bismuth form a brittle regulus colored like bismuth. Equal parts of bismuth and silver form a mass not so brittle as the former. A small portion of bismuth increases the brightness, hardness, and sonorousness of tin. The color of copper is rendered less red, but not white, by bismuth. Equal parts of bismuth and lead form a dark grey compound. Bismuth may be united with iron, by a strong heat. It does not unite with zinc or with regulus of cobalt, or only in a small proportion. 5. The uses of bismuth are, for making *powder* with tin; for *foldering* some metals; for *printing types* (Homberg advises one part of bismuth and one of tin to be added to twelve parts of the common composition, which is one part of copper, one part of regulus of antimony,

and five parts of lead); for *foils for mirrors*, the common mixture for this being one part of tin, one part of lead, two parts of bismuth, and ten parts of mercury; for *anatomical injections*, equal parts of lead, tin, and bismuth, to which some add a little mercury, forming a mixture sufficiently fusible; for *imitating silvering on wood*, for which purpose it is ground, applied with whites of eggs, and burnished; for *purifying gold and silver by expellation*, for which it is preferable to lead, as it more effectually destroys imperfect metals, promotes the *verification* of earths and calxes, and combines with sulphur, forming a very fusible mass; and lastly, for *rendering some metals fitter for being cast into moulds*, as a small portion of it increases their fusibility.

(u) BISTRE is a brown pigment, consisting of the *finer parts* of *water from the stones*.

(w) BITTERN is the bitter saline liquor which remains after the crystallization of sea-salt in sea-water, or the water of salt springs. See WATER (SEA).

must allow this latter opinion to be the most probable: for, first, no body the origin of which is certainly mineral, contains the smallest portion of oil. Even sulphur, which of all minerals approaches most to the nature of bitumens, and which all the ancient chemists have considered as such, does not contain, as Stahl has demonstrated, the smallest vestige of oil.

2dly, It is probable that the qualities by which bitumens differ from resins and other oily matters, vegetable and animal, are either the natural effects of time upon these oily matters converted into bitumens, or of an alteration produced upon them by mineral acids; or rather they are the effect of both these causes united.

Thirdly, by combining mineral acids with vegetable oils, compounds may be formed much resembling natural bitumens, and to which perhaps nothing but a sufficiently long digestion is wanting to render them true bitumens.

Fourthly, we cannot doubt that the vegetable and animal matters continually destroyed on the surface of the earth, the juices of which are capable of penetrating further, must introduce into the earth much oily matter, which, in time, may become bitumen.

Besides, natural history proves, that many entire vegetables and animals have been buried in large quantities, and even at considerable depths, by the various accidents and revolutions which have happened upon the earth; for under ground immense beds of turf are daily found, and large banks of half-decomposed, bituminous, and petrified fossil wood, which can be nothing else but considerable portions of the surface of the earth, thus buried by accidents too ancient to be remembered. All these matters are sufficient to furnish the earth with a large quantity of truly oily substance, which probably can be formed only in the organized bodies of vegetables and animals.

Junker describes, after Neuman, the Prussian amber mines, which are the richest known. First, at the surface of the earth is found a stratum of sand. Immediately under this sand is a bed of clay filled with small flints of about an inch diameter each: under this clay lies a stratum of black earth or turf, filled with fossil wood, half-decomposed and bituminous: this stratum is extended upon a bank of minerals containing little metal, excepting iron, which are consequently pyrites: lastly, under this bed the amber is found scattered about in pieces, or sometimes accumulated in heaps.

If we add to all this, that in amber are frequently included insects and fragments of plants, we shall find a further probability that bitumens are of vegetable original.

It is true that amber, petroleum, and other bitumens are found in grounds where no fossil vegetable matters exist; but it is easy to conceive that these matters may have been destroyed, and their appearance changed by time, particularly as the different natures of soils contribute much to the preservation or destruction of vegetable and animal substances.

Those bitumens which are sufficiently compact to be cut and polished, such as amber and jet, are formed into toys and ornaments, as necklaces, heads for canes, buttons, and mourning ear-rings.

Bitumens are also used for the preparation of very solid and beautiful oil varnishes. For this purpose amber is chiefly used. See AMBER and VARNISH. (x)

### CVIII. BLACKNESS. (y)

(x) Notwithstanding the reference made in the text to *amber* and *varnish*, both these articles are omitted by the author: we shall therefore make some addition concerning *amber varnishes*.

A *fine black varnish* may easily be made by dissolving amber previously melted in a crucible till it is rendered black, in boiling linseed oil. But the solution of amber without decomposition, by which its color is altered, in linseed or other expressed oils, is more difficult, and has been unsuccessfully attempted by Neuman and other chemists. Hoffman says, that he reduced amber and oil of olives to a gelatinous mass by placing the glass-vessel containing them in Papin's Digestor, one third part of which was full of water. The experiments of Dr. Stockars are more decisive. He says, that, by continuing a simmering heat during twelve hours, and by confining the vapors as much as stone-ware vessels would bear, powdered amber was perfectly dissolved in expressed oils, in turpentine, and in balsam of copaiba. He prevented the vessels from bursting, by making small notches in the corks with which he stopped them. The solutions of amber in oils of rape-seed and of almonds had a fine yellow color; in oil of linseed a golden color; in oil of poppy a yellowish red; in oil of olives a beautiful red; in oil of nuts a deeper red; in oil of bays a purplish red. Solutions of amber in turpentine and balsam of copaiba had a deep red color, and when cooled, formed hard brittle red masses. All these solutions were easily miscible with spirit of turpentine. Those made with oils of linseed, bays, poppies, and nuts, with balsam of copaiba, and with turpentine, being diluted with four times their quantity of spirit of turpentine, formed hard, tenacious, glossy varnishes, which dried sufficiently quick. See Dr. Stockars's *Specimen Inaugurale de Succino*, Leyden, 1760.

Amber may be rendered clear and pellucid by two methods. 1. By cementing lumps of it with sand, during 40 hours, in an iron pot. 2. By digesting them during 20 hours in boiling rape-seed oil.

A *tincture* may be extracted from amber by rectified spirit of wine, or by sweet spirit of vitriol.

From 16 oz. of coarse amber Neuman obtained, by distillation, eleven ounces six drams of oil, four drams and a half of salt, (see SALT of AMBER) one ounce and a half of water, and nearly one ounce of caput mortuum.

(y) BLACKNESS Dr. Lewis, in his *Philosophical Commerce of Arts*, has written copiously concerning the substances capable of communicating blackness. What we shall say on this subject shall be chiefly extracted from that work.

"The native black coloring materials are, 1. *Black chalk*, or *black marking stone*, which seems to be a stony lithonious substance, insoluble by acids, and capable of being rendered friable and red by fire. It stains freely. When powdered, it does not lose its blackness, and may then be formed with oil into a paste, or with water into a slimy mass; which properties render it useful to painters. 2. *Pitcoal* mixed with oil produces a brownish black. 3. *Black sand* found in Virginia, strewn upon writing while yet wet, dries and gives lustre to the ink. This substance might be used in oil painting to give a sparkling black. What this substance is Dr. Lewis has not mentioned. I have essayed a black sparkling powder usually sold for strewn upon writing, and found it to consist of minute particles of the lead-ore called *galena*. 4. *Black lead*, the color of which is rather a deep shining blue than a black, is smooth and unctuous, and hence is used, as soap and oil are, to prevent the friction of machines. It is insoluble by acids, and unfusible by fire: in close vessels it is unalterable by fire; but by a long calcination in an open fire it is mostly volatilised, emitting, according to Lawson, (*Dissertatio de Nihilo*) inflammable blue flowers, and the residuum is a yellow calx, which being reduced by Mr. Queff, (*Le Boulais Art*, 1754) seemed to be a mixture of iron and tin. Black lead may be readily mixed with melted sulphur, and of this composition pencils are formed much inferior

## CIX. BLACK - JACK. (2).

CX. BLOOD. Blood is well known to be a red liquor in most animals.

ferior to those made of slips of either black lead fitted into pieces of cedar wood. 5. *Black vegetable juices.* The excellent black varnish of China and Japan is a native juice exuding from incisions made in certain trees, one of which is said to be that, the fruit of which is brought to Europe, called *amarantium*. Anacardium contains a black juice which gives to linnen and cotton a reddish brown stain, which, by exposure to air, becomes black, and is incapable of being discharged by washing or boiling with soap or alkali. 6. *Callosities.* A natural varnish is said to be produced from the tree called *maackia*. 7. *Callosities.* A fluid as black as ink, and which is said to be fit for the same purposes.

*Black coloring materials produced by fire.* 1. *Coal.* Coal, when cut into or powdered, is often used for this purpose articles use the most blackish of trees, chiefly of the tortoise wood, willows and vines, taken from the bark and pith. The coal of bones and other animal substances is glossier and deeper colored than vegetable coals; that of ivory is superior to the rest. 2. *Soots.* Soots are better than coals, and more easily miscible with oil or water. A part of wood soot is soluble in water. From an infusion in wood soot in water is prepared the brown pigment called *terra*, used for painting in water-colors. The soot of the foot blacks is *improvable*, usually prepared by burning in an oven one drugg and pieces of pine-bark left in the woods for a long season. Soots prepared by burning small pieces of wood or of mineral substances very slowly under a copper pan, were found by Dr. Lewis to be not different from those prepared from oils and resins; and, like these, contained nothing soluble in common water, as the soot collected in common chimneys does. See SOOT.

The black-coloring materials produced by mixture are, 1. A solution of green vitriol in water, added to an infusion of galls or some vegetable astringent, is the basis of black inks, and black dyes for the uses of calico printers, tanners of leather, hatters, dyers, &c. The color given by this mixture adheres permanently to silk and wool, but may be discharged from linnen and cotton by washing. If the water employed for dis-

solving the vitriol, or infusing the galls, have been distilled, or is a common spring water, or fresh rain water, the color produced will be bluish; and if the water be any putrid or alkaline quality, the color produced will have a purple or reddish tinge. The blackness given by galls is much improved by addition of *fermentum*. Vegetable astringents do not produce blackness by mixture with solution of green vitriol. Thus the Peruvian bark is said to give a greenish color. See INK. 2. A solution of silver in nitrous acid gives black stains to solid white animal substances, to agate, and some other stones, afterwards exposed to the sun and air. Bones and hair at first receive no stain, but sooner or later, as they happen to be more or less exposed to the sun and air, they become of a reddish or purple color, which gradually changes to a brown, and afterwards to a black. Mr. Schaeffer (*Art. Natur. Curios. vol. 1.*) says, that white chalk moistened with solution of silver, on exposure to the sun, acquires a purplish black color on its surface, which continues to be interrupted by threads shading parts of the chalk. If the chalk, thus moistened with solution of silver, be dried in the shade or by fire, no color will be produced. The color was given by this method to white chalk, talk, or plaster of Paris. The action of solar light also gives a dark color to the white precipitate of bitumens, and to sweet mercury. 3. A black stain is given to paper or other white substances, by *infusion of iron in acids*, when these substances are afterwards exposed to phlogistic or sulphurous vapors. See INK. (SYMPARTIC). 4. *Black paint.* *Melted with sulphur* form a black or blackish mass useful for taking casts from moulds, as it is less brittle than sulphur alone. Agricola Blon found that a black color may be produced by mixing blue, red, and yellow pigments; and Mr. Cartel directs that fifteen parts of blue should be mixed with five parts of red, and three of yellow, and that each of these colors should be very deep. Dr. Lewis tried such mixtures, but produced only a brownish or greyish black.

(2) BLACK-JACK, or BLEND, is a mineral, called also *false galena*. See GALENA (FALSE).

circulating in their vessels during life, and the common source whence all the necessary and superfluous animal liquids are derived. (a)

Blood newly drawn from a sound animal gives no sign of an acid or alkaline quality. It has a sweetish and somewhat saline taste. When left to itself, it coagulates, and quickly passes to a fermentation at first a little acid, and afterwards entirely putrid, in the same manner as all other perfectly animalised substances.

This liquor contains nothing volatile by the heat of boiling water, but a pure phlegm. Thus when blood is distilled in a water-bath, it is only dried, not entirely decomposed. By this drying it loses  $\frac{1}{3}$  of its weight. The residuum being distilled in a naked fire, yields volatile alkali, and animal oil, at first thin, and afterwards thick: in the retort a charry residuum remains, which can difficultly be reduced to ashes, from the lixiviation of which a little common salt may be obtained.

From this analysis, which is almost all that chemists have done to discover the nature of the blood, it appears that this liquor contains the same principles as all other perfectly animalised matters. But a more accurate examination might probably be made of it by separating at first from each other several different substances, of which the blood is only a collection or mixture, and then by analysing each of these substances, as has been done with milk.

In fact, the blood being opaque, or not very transparent, appears to be, as milk is, nothing else than a mixture of several heterogeneous matters confounded together, without being dissolved by each other. It is known, that, when the blood is no longer circulated in the vessels of the animal, but left at rest in a vessel, it coagulates and separates spontaneously into a red mass, and a white liquor, or serum, in which the red mass floats; and that by washing, the red part of this mass may be carried off, and the remaining matter is white and gelatinous. There are then three distinct matters in the blood which seem to correspond with those contained in milk; that is, the serum of the blood corresponds with the whey of milk; the white gelatinous matter, with the cheesy part; and lastly, the red globules with the butyraceous substance.

It is so much more probable that the red part of the blood is oleaginous, as anatomists, who have examined the blood by microscopes, have observed that this red part is composed of globules swimming in a white liquor, and as all oily matters, when well mixed, but not dissolved in a watery fluid, have this globular appearance. (b)

This being established, if the blood were to be examined more exactly than it has hitherto been, it would probably be necessary to begin by separating from each other the three above-mentioned substances, each of which ought afterwards to be subjected to experiments and analyses, as has been done with milk. It is probable that this method of analysing blood would throw new light upon its

(a) The color of blood, like that of many other substances, is affected by exposure to air. It acquires the scarlet color by exposure to air, and arterial blood loses its vivid red color by exclusion from air.

(b) The red particles of blood are said to have an annular form.

nature and principles, which are yet very imperfectly understood, as well as those of other animal matters.

The purely gelatinous parts of the blood are probably not different from any other animal jelly : but it is to be presumed that some peculiar salts might be obtained from the serous parts, as have been from milk and from urine ; and that the red globular part would be found to be oleaginous. The acid, or volatile alkaline principles which would be obtained from the red part of the blood would determine whether or not it is a truly animal oil, or fat. If it be true, as Mr. Homberg and Mr. Macquer affirm, that some acid may be obtained by analysing the blood, it would probably be found to belong to this red substance.

Lastly, it is evident that whatever knowledge could be acquired on this subject by well-conducted experiments, must extend and encrease an interesting branch of our knowledge, namely, that concerning animal economy, (c)

#### CXI. B L U E. (d)

(c) Dr. Fordyce, in his very excellent Elements of the Practice of Physic, says, that the white gelatinous matter of the blood, or *coagulable lymph*, continues fluid while circulating with any degree of heat betwixt 30 and 120° of Fahrenheit's thermometer ; but that it is coagulable very soon after it is taken out of the body in any heat, in motion, or in rest ; and that its coagulation may be prevented by saturating the blood with sea-salt, or perhaps with some other neutral salt. The coagulum is rendered soluble in boiling water, by putrefaction, by concentrated acids, caustic alkalis, calcareous earths, and by some metallic salts. He observes also, that the coagulable lymph is more fluid, and is not so easily coagulable when the arteries of the person from whom the blood is drawn act more strongly than they usually do ; in which case, the red particles and this lymph can separate more easily from each other according to their densities, the former falling to the bottom, and the greatest part of the latter forming upon the upper surface a very viscid tough mass called the *buff*. By putrefaction the coagulable lymph and serum are converted into a mucilaginous matter, not coagulable by any of the methods recited above, which mucilaginous matter may be converted by further putrefaction into saline substances and calcareous earth. The red part of the blood is readily soluble in water, but not in serum, nor in a saturated solution of neutral salts. By the first stage of putrefaction this red part of blood is broken down into smaller particles, its color is rendered darker, and afterwards it is converted to a mucilage soluble in serum.

(d) BLUE COLORING MATERIALS. No blue materials for dyeing consist of animal or mineral substances. Concerning the blue glass called *smalt*, prepared from the ore of regulus of cobalt ; the preparation of iron called *Prussian blue* ; and the preparation of lapis lazuli called *ultramarine* or *azure*, see *SMALT*, *AZURE*, and *BLUE* (Pigments). The blue color of flowers is so perishable as to be of little use in dyeing. It is extracted from many by infusion in water, but not in spirit. It is changed by acids to a red not more durable than the original blue ; by marine acid to the most florid red ; and it is changed by alkalis and by lime-water to a green, which afterwards becomes a yellow. The green by lime-water is the more permanent and beautiful, and has been formed into lakes for painting. The two principal vegetable substances used for dyeing of a blue color are *indigo* and *woad*. These are fecules or sediments deposited by fermentation from infusions of the leaves of the plants *anil*, and *woad*, or *glaston*. Hellot thinks, that a similar blue dye might be obtained from most other vegetables, and that the green of vegetables is caused by a mixture of blue and yellow coloring particles, of which the blue is the most durable, and least affected by fermentations. The colors given by both indigo and woad are at first green, but are soon changed, by exposure to air, to blue. A blue tincture may be made from *nephritic* wood, which has not been applied to any use. The essential oils of *camomile*, *milfoil*, *pimpinella nigra*, are blue, and by keeping become green and yellow. See *DYEING*.

**CXII. BLUE (PRUSSIANA).** Prussian blue is a precipitate of iron with a superabundant quantity of phlogiston, from which it receives a very beautiful color.

This blue, which is successfully used in painting, was discovered, like most other things, by accident, and about the beginning of this century.

A chemist of Berlin having successively thrown upon the ground several liquors from his laboratory, was much surprised to see it suddenly stained with a most beautiful color. He then recollected what liquors he had thus thrown upon each other, and having made a similar mixture in a vessel, he saw the same blue color appear. As he perceived that this discovery might be profitable to him, he did not publish the process, but prepared this blue for the use of painters, who found that it might be substituted for ultramarine, a very dear color, and from that time made much use of it.

An account of this blue, called *Prussian* or *Berlin blue*, from the place where it was made, was published in the Berlin Memoirs for 1710, but no description was given of the process for making it.

Several chemists undoubtedly attempted to discover it: accordingly it was discovered, and in the year 1724 Dr. Woodward published it in the Philosophical Transactions. The process succeeds very well, and is as follows:

Alkalise together four ounces of nitre and as much tartar. *See ALKALI (EXTEMPORANEOUS)*. Mix this alkali well with four ounces of dried bullock's blood, and put the whole in a crucible covered with a lid in which there is a small hole: calcine with a moderate fire till the blood be reduced to a perfect coal; that is, till it emits no more smoke or flame capable of blackening any white bodies that are exposed to it: increase the fire towards the end, so that the whole matter contained in the crucible shall be moderately, but sensibly red.

Throw into two pints of water the matter contained in the crucible, while yet red, and give it half an hour's boiling: decant this first water, and pour more water upon the black and charry coal till it becomes almost insipid: mix together all these waters, and reduce them by boiling to about two pints.

Also dissolve two ounces of martial vitriol, and eight ounces of alum in two pints of boiling water: mix this solution when hot, with the preceding lixivium, also hot. A great effervescence will then be made. The liquors will be rendered turbid, and will become of a green color more or less blue, and a precipitate will be formed of the same color. Filtrate, in order to separate this precipitate, upon which pour spirit of salt, and mix them well together, by which means the precipitate will become of a fine blue color. It is necessary to add rather too much spirit of salt than too little, and till it no longer encreases the beauty of the precipitate. The next day wash this blue till the water comes off from it insipid, and then gently dry it. Such is the process by which Prussian blue is made. Chemists, after having discovered it, endeavored to find the theory of it, and to explain the appearances in the several operations of the process. There have been several opinions concerning the nature of Prussian blue.

Mr. John Brown of the Royal Society of London thinks, that this blue is the phlogistonous or phlogistic part of iron, disengaged by the lixivium of bullock's blood, and applied to the earth of alum. This opinion has been adopted by Dr. Geoffroy in the Memoirs given by him on this subject, which are found in the collection of the Academy of Sciences for the year 1725.

The



The Abbé Menon, a correspondent of the Academy of Sciences, in Memoirs printed amongst the collection of the *Spacious Librarian*, published by the Academy, advances and endeavors to prove that Prussian blue is nothing but iron entirely freed from all saline matter by the phlogiston of the alkali, dissolved, and precipitated with its natural color, which, he pretends, is blue. He thinks that the use of the alum is to diminish the intensity of the color by the whiteness of its earth.

Lastly, Mr. Macquer, having examined this matter in all its extent, has published a memoir amongst those of the Academy of Sciences for the year 1755, in which he concludes, after having related many experiments, that Prussian blue is nothing but iron impregnated with a superabundant quantity of phlogiston, which it receives from the phlogisticated alkaline precipitate. The experiments and discoveries made by this chemist are as follow.

Mr. Macquer first observes that very pure alkaline salts separate from, as they do all metallic substances, from acids; and that iron so precipitated has a color more or less yellow, and is soluble by acids.

If, on the contrary, this precipitation of iron be made by an alkali previously calcined with an inflammable matter, then a precipitate is formed, more or less green or blue, as the alkali was more or less phlogisticated.

If an acid be poured upon this green precipitate, experiments shew that the acid dissolves one part of it, and does not act upon the other. This proves that the green precipitate is not homogeneous, but a mixture of two precipitates, one of which is soluble, and the other is insoluble by an acid.

As the precipitate which resists the action of acids is very blue, when separated from that which the acid has dissolved, and as the green color of the mixed precipitate is a mixture of yellow and blue; the author concludes that the part dissolved by the acid is yellow, and consequently that this portion of green precipitate is entirely similar to the iron which pure alkalis separate from acids.

As to the blue precipitate, as it not only resists the action of acids but also of magnets, it might not be known to be iron, if a slight calcination did not at once deprive it of its blue color, and render it entirely similar to other iron.

These facts prove that Prussian blue is nothing but iron united with some matter which gives it a blue color, and the property of resisting the action of acids and of magnets.

Mr. Macquer has further discovered that fire is not the only means by which the Prussian blue may be deprived of all the properties, by which it differs from ordinary iron.

A very pure alkali produces also the same effect. He has also discovered, that the alkali which has thus deprived the Prussian blue of all the properties which distinguish it from ordinary iron, becomes by that operation entirely similar to the phlogisticated alkali used for the preparation of Prussian blue.

These facts seem to demonstrate that Prussian blue is nothing else than iron, which becomes blue by impregnating it with with a matter which the alkali is capable of giving to it or of separating from it, according to circumstances; that is to say, that when the alkali is impregnated with this matter, and is applied to iron dissolved in an acid, it then combines with this acid, and precipitates the iron, to which it transfers at the same time the matter which changes the iron into Prussian blue. But if on the contrary Prussian blue be applied to pure

alkali, then this alkali entirely dissolves the coloring matter of the Prussian blue, and takes it from the iron, which is thus reduced to its ordinary condition.

By a more particular examination of this alkali, impregnated with the coloring matter of Prussian blue, either by calcination with an inflammable matter, or by taking the color from Prussian blue itself, Mr. Macquer found that its alkaline properties were so much more weakened, as it was impregnated with a larger portion of this coloring matter. This induced him to presume, that by giving it a sufficient quantity of Prussian blue to discolor, it might be entirely saturated with this coloring matter : and the event entirely answered his expectation.

By applying much Prussian blue to an alkali, this latter was so saturated that it no longer discolored the blue when boiled together, and upon trial, was found to possess no longer any alkaline qualities.

A solution of iron by any acid poured into this alkali, saturated with the coloring matter of the Prussian blue, forms immediately a precipitate, not green, composed of yellow and blue, the former of which must be separated by an acid from the latter to obtain this of a pure blue color, as in the process for the preparation of Prussian blue, but a single homogeneous and a perfect Prussian blue. This effect ought necessarily to happen, the saturated alkali contains no part purely alkaline which can occasion a precipitate of soluble iron, as pure alkalis do.

But an essential phenomenon, and not observed by any former chemist, is, that it is not merely by the action of the acid, which dissolves the iron, that the coloring matter is applied to the iron, and thus the Prussian blue formed ; but that the affinity of this matter to iron contributes also to produce this effect. The author has demonstrated this truth by the following decisive experiment.

If any pure acid be poured upon an alkali perfectly saturated with the coloring matter of Prussian blue, this acid contracts no union with this alkali, nor is any-ways neutralized, and consequently is incapable of separating the coloring matter of Prussian blue. It only procures this separation when it is united with iron, the affinity of which to the coloring matter, being joined to the affinity of the acid to the alkali, form a sum of affinities capable of occasioning the separation of which we treat.

In this operation, therefore, there is a very distinct example of the effect of double or united affinities. *See AFFINITY.* This example is even so much more complete, as it is amongst the most general that chemistry furnishes. For according to Mr. Macquer's observations, iron is not the only metallic substance, the affinity of which being united with that of the acid, procures the separation of the coloring matter of the Prussian blue from the alkali ; but any metal substance dissolved in any acid separates the phlogistic matter from all alkalis, fixed or volatile. This is ascertained by Mr. Macquer's experiments, a detail of which may be seen in his memoir.

Another no less important phenomenon, which none of the chemists who have endeavored to explain the theory of Prussian blue had observed, is, that earths have not the same affinity as metallic substances with the phlogistic matter of Prussian blue. Hence if an alkali saturated with this coloring matter be poured into a solution of alum, no decomposition is effected, nor is any precipitate formed.

formed. The alum continues alum, and the saturated alkali remains unchanged.

After this experiment Mr. Macquer reasonably concludes, that the alum added in the operation of Prussian blue does not directly contribute to the production of this blue. The purpose to which it serves is as follows.

This chemist proved by many experiments, that alkali salt can never be entirely saturated with the coloring matter of Prussian blue by calcination. This being established, it is certain that alkalis, calcined with inflammable substances to make the proper lixivium for Prussian blue, still remain alkaline. Hence it happens that when they are mixed with a solution of green vitriol, they form by their purely alkaline part a yellow precipitate, so much more copious as this purely alkaline part is itself more copious. But nothing is more capable of spoiling the color of the portion of iron precipitated in Prussian blue than a mixture of this yellow or olive-colored precipitate; therefore a large quantity of acid must be employed, that this yellow precipitate may be entirely dissolved, if we mean to have a very fine blue.

Part of these inconveniencies is avoided by mixing a solution of alum with a solution of green vitriol. By this means, the purely alkaline part of the lixivium is mostly employed to precipitate a greater or less quantity of the earth of alum, and consequently the quantity of yellow ferrugineous precipitate is much diminished. But the earth of alum being of a fine shining white does not in the least alter the purity of the blue color, but enlivens it, and lessens its intensity; which is frequently no inconvenience, because the Prussian blue, when it is not of the finest color, is always too dark and black.

It follows from what has been said, that when Prussian blue is to be made with a lixivium not saturated, it is a matter of indifference whether the green precipitate is to be again dissolved, or the alkaline part of the lixivium saturated with alum or with an acid, before the precipitate is formed. The only difference which can proceed from these modes of management is, that in the former case all the part of the precipitate which is not Prussian blue is redissolved by an acid; whereas in the latter case, this mixed precipitation is prevented, and nothing is thrown down but true Prussian blue.

It is proper to observe, concerning the theory of Prussian blue, that most alkalis obtained from the ashes of vegetables, being combined by their combustion with a portion of inflammable matter, are capable of furnishing a quantity of Prussian blue proportionable to the quantity retained by them of this inflammable matter, even without the necessity of mixing them with a solution of iron, because they always contain a little of this metal dissolved, some of which may be found in almost all vegetables; therefore it is sufficient for this purpose to saturate them with an acid. These materials which form Prussian blue in alkaline salts occasion their impurity, and require much trouble to be perfectly separated.

Some chemists had even perceived the production of this blue in the saturation of alkaline salts, before the discovery of the Prussian blue: and Henkel particularly, who had observed it in the saturation of sal soda, or fossil alkali, recommended to chemists an enquiry concerning the nature of this blue. Thus chemists had already acquired some sort of knowledge on this subject, and therefore the Prussian blue could not have long remained unknown, even if accident

but had not presented it in so striking a manner to the chemist of Berlin, who was the first who prepared it in sufficient quantity for the uses of painters.

**CXXIII. BOILER.** Boles, or bolus earths, are clays which adhere to the finger, when applied dry, and which are colored, yellow and red, by a ferruginous earth. *See CLAY.*

**CXXIV. BOLOGNIAN STONE.** *See STONE.*

**CXXV. BONES.** (c)

**CXXVI. BORAX.** Borax is a saline matter, with all the properties of a

It is soluble in water, and crystallizable nearly as alum is; with this difference only, that it requires a little more water for its solution, and retains somewhat less in its crystallization.

When exposed to fire, it at first undergoes the liquefaction occasioned by the water of its crystallization, and is then calcined, as alum is, but is not so much melted and fused during the operation.

If the fire be increased to a melting heat, the borax is pretty easily fused, and is converted into a vitreous matter, or saline glass: and when it is mixed with earths of any kind, it acts as a flux, and converts them into more or less transparent glasses according to their natures. *See VITRIFICATION.*

Glass of borax is very friable, easily tarnishes in the air, and becomes mealy, nearly as the alkaline basis of sea-salt does. It is entirely soluble in water; and when the solution of it is evaporated, borax is again formed in crystals, as it was before its fusion.

Borax then suffers no decomposition by fire, even in open vessels, and certainly, therefore, not in close ones.

But it may be decomposed by the vitriolic, nitrous, and marine acids, which unite with the saline alkaline matter which is its basis, and form with it exactly the same neutral salts as those which result from the union of these acids with the marine alkali; that is to say, the vitriolic acid forms Glauber's salt; the nitrous acid forms cubic nitre; and the marine acid forms sea-salt.

When acids combine thus with the alkaline basis of borax, they separate from it a saline substance of a singular nature, and little understood, called *Sedative Salt*. *See SALT (SEDATIVE).*

We are far from knowing as much concerning borax as is desirable. We are even ignorant of its origin, which might supply the want of a perfect analysis, and give light to the nature of this saline substance.

As borax is not found in Europe, it is brought from the East-Indies in a state which only requires a slight purification, which is given to it by the Dutch and

(c) BONES are totally soluble in concentrated acids of vitriol, nitre, and sea-salt, and may be softened by the acetic acid diluted. From two ounces of ox-bone Newman obtained by distillation two drams of empyreumatic phlegm, one dram of volatile spirituous spirit, two scruples of volatile alkali, two scruples of fixed oil, and one ounce, three drams, and two scruples of residuum.

Dr. Lewis observes, that bones exposed to a heat gradually raised are rendered white, opaque, and friable; and when exposed suddenly to a violent heat, are rendered hard, semi-transparent, and sonorous. Bones and horns may be stained by the common dyeing infusions and decoctions of vegetable and animal substances, and by metallic solutions.

Venetians

Venetians who are the chief merchants of it. But it is not yet known whether this matter be a natural or an artificial substance, nor whence, nor how it is obtained.

Our ignorance concerning borax is certainly owing to the interest, which they, who make a lucrative commerce of it, have to keep every thing concerning its origin secret.

However that be, notwithstanding the resources which chemists possess of discovering what is hid from them by their experiments, it appears that they were long in a state of indifference concerning borax. Satisfied with employing it in their operations, in which it is very useful as a flux, they long used it without attempting to subject it to proper proofs for the discovery of its nature.

In the writings of Becher and Stahl we scarcely find any thing concerning borax. The examination by chemical means of this substance, which ought to excite the curiosity of chemists, has been begun only in these latter times; and it is to the praise of the French, that almost all the knowledge we have concerning it we owe to them alone.

Homberg was amongst the first who undertook a set of experiments on borax, by which the sedative salt was discovered, which was a new substance, and entirely unknown before him. Homberg obtained the sedative salt from borax, by distilling it with vitriol; and imagining that he discovered a sedative or quenching power in it, he called it the *Narcotic Salt of Vitriol*, or *Sedative Salt*. This chemist did not well understand the theory of his experiment; but that is not surprising in matters so new.

The younger Lemerj, who after Homberg made many experiments on borax, discovered that sedative salt may be obtained from it not only by the vitriolic acid, but also by the nitrous and marine acids. This discovery was the more important, as it naturally led to further; but he seems to have been prevented by other pursuits from continuing this subject as it ought to be.

Homberg and Lemerj obtained sedative salt only by distillation or sublimation, which, particularly in this case, was a long and embarrassing operation. M. Geoffroy has improved upon their discoveries, by shewing the method of obtaining the same salt from borax by acids with evaporation and crystallization only, in greater quantity and with less trouble. We are also obliged to him for having first demonstrated that borax contains the basis of sea-salt. This truth he has firmly established, by obtaining a true Glauber's salt by mixing vitriolic acid with a solution of borax.

Lastly, Mr. Baron, Member of the Academy of Sciences, and of the Faculty of Medicine at Paris, proved by many experiments that sedative salt of borax may be obtained by means of vegetable acids, which had not been done before him. He has also proved, that sedative salt is not a combination of an alkaline matter with the acid employed to obtain it, but that it exists ready formed in borax, of which it is a principle or constituent part; that the acids employed to extract it do only disengage it from the alkali with which it is united; that this alkali is entirely similar to that of sea-salt; that sedative salt may be re-united with its alkali, and again form borax; which is a compleat proof that borax is nothing else than a compound of sedative salt, and marine alkali.

Nothing more then remains to have, on the nature of borax, all the knowledge we can desire, than to discover what this sedative salt is. The experiment by which Mr. Baron found that this salt is capable of decomposing nitre and marine salt, by separating the acids of these salts by help of fire, seems to shew that vitriolic acid is one of the principles of the sedative salt. But to prove this decisively, the sedative salt itself must be decomposed. This is the subject of Mr. Bourdelin's late admirable experiments. Although this able chemist has not been able to accomplish his purpose by all the methods which the most profound chemistry can suggest, his experiments are nevertheless useful, as they may prevent others from employing their time and labor in making them, and also because they make us better acquainted with the properties of the sedative salt. See SALT (SEDATIVE). (f)

CXVII. BRAINS. (g)

CXVIII. BRANDY. (b)

(f) *Borax*, when crude, as it is brought from the East-Indies, is called *Tircal*. In this state, it consists of small, yellow, glutinous crystals. It is said to be refined by lime water. Refined borax consists of large, white, eight-sided crystals, each of which is composed of small, soft, bitterish scales. It is difficultly soluble in water, to which it gives a glutinous quality, and hence is used by dyers to give a gloss to silks. It is also soluble in spirit of wine, to the flame of which it gives a green color. By repeatedly moistening it, while it is considerably heated, it may be entirely sublimed. Borax renders all earths and stones fusible by fire, and hence is used for the assaying of ores. It also facilitates the fusion of metals; and is particularly useful when small particles of metal mixed with dirt and ashes are to be melted together; as it promotes the fusion of the metal, and the vitrification of the other matters, by which the particles of metal may disengage themselves, and collect into one mass. It is further useful in the fusion of metals, as it defends their surfaces from the combined action of air and fire, by which imperfect metals are calcined. Crucibles in which gold and silver are melted ought to be previously glazed on their inner surfaces with borax, that when the metals are poured out, no particles may adhere to the sides of the crucibles. Gold is rendered pale by fusion with borax, which effect is prevented by adding a little nitre or sal-ammoniac, or is remedied by remelting the gold with either of these salts. Dr. Lewis observes, that borax

also renders brass and Prince's-metal pale, and at the same time acquires a deep red color. This color it probably receives from some part of the copper contained in these compound metals, as it acquires the same red color by fusion with copper. Borax is not, as some suppose, a substance capable of reducing or reviving calcined metals, but is

principal use of borax is to facilitate the soldering of metals, which it does by accelerating the fusion of the surfaces of the metals to be joined, and by clearing them from any calx or other matter by which they might be prevented from being perfectly applied to each other. Borax is also used for the preparation of some fine glasses, and imitations of precious stones; because the glasses prepared by fusing it with earths are very hard, compact, bright, and very transparent; but by long exposure to air they lose much of their lustre, become cloudy, and when the quantity employed has been large, even opaque.

(g) BRAINS. From 16 oz. of ox's brains, Neuman obtained by distillation six ounces, two drams, and two scruples of a colorless phlegm; four ounces and four scruples of a volatile, empyreumatic spirit; which being rectified, produced two scruples of a volatile, concrete salt, and one ounce of caput mortuum, from which, by elixation, were procured 25 grains of fixed salt.

(b) BRANDY is an ardent spirit distilled from wine. For its properties, *See SPIRIT*. It may be imitated by adding to very pure malt spirits some dulcified spirit of nitre.

**CXIX. B R A S S** (*i*). Brass, called also *Latten*, is a mixture of very pure copper, with a fourth part of very pure zinc, by which the color of the copper is rendered of a fine golden yellow. This is undoubtedly the most useful and necessary of all the mixtures of copper and other metals, chiefly on account of the copper's preserving so much of its ductility, when combined with that proportion of zinc.

(*i*) **BRASS.** As the manufacture of brass is important in commerce, a detail of the process by which it is made may be acceptable. The calamine is previously to be prepared by cleansing it from adhering earth, stone, or other matters; by roasting or calcining it; and by grinding it into a fine powder. The calcination, by which moisture and small portions of sulphur and other volatile matters are dissipated, may be performed either in a reverberatory furnace, in which the calamine is kept till it be thoroughly red hot; and that this heat may be more equally given to it all at the same time, it ought to be frequently stirred; or by setting fire to a conical pile, composed of horizontal layers of calamine, and of charcoal placed alternately one upon the other, and of a lower stratum consisting of large pieces of wood; in which lower stratum are four horizontal channels, through which the air maintaining the fire passes to the center, and thence arises through a chimney or perpendicular empty space, left for that purpose, along the axis of the conical pile. If the calcining heat be too intense or too long continued, part of the contained zinc may be dissipated; and if it be not sufficiently intense, or long enough continued, the volatile matters will not be entirely expelled, and the texture of the stone will not be sufficiently broken to prepare it for the subsequent grinding. The length of time and degree of heat requisite for the calcination of calamine, are different according to the qualities of that mineral. The calamine thus cleansed, calcined, and ground, is to be mixed with about a third or fourth part of powder of charcoal, or of pit-coal, as is done in some parts of England. The malleability of the brass is diminished by the use of pit-coal, which is therefore employed only for the preparation of coarser kinds of brass. To this composition of calamine and coal some manufacturers add common salt, by which the process of making brass is said to be hastened. In Goslar, where the cadmia ad-

hering to the inner sides of furnaces is employed, instead of native calamine, a small quantity of alum is added, by which they pretend the color of the brass is heightened. With this composition, and with thin plates or grains of copper, the crucibles are to be nearly filled. The proportion of calamine to the copper varies according to the richness of the former, but is generally as three to two. The copper must be dispersed through the composition of calamine and coal, and the whole must be covered with more coal till the crucibles are full. The crucibles thus filled are to be placed in a furnace sunk in the ground, the form of which furnace is that of the frustum of a hollow cone. At the bottom of the furnace, or greater basis of the frustum, is a circular grate, or iron plate. This plate is covered with a coat of clay and horse-dung to defend it from the action of the fire, and pierced with holes, through which the air maintaining the fire passes. The crucibles stand upon the circular plate, forming a circular row with one in the middle. The fuel is placed betwixt the crucibles, and is thrown into the furnace at the upper part of it, or the lesser basis of the frustum. To this upper part or mouth of the furnace is fitted a cover made of bricks or clay, kept together by bars of iron, and pierced with holes. This cover serves as a register. When the heat is to be increased, the cover is to be partly or entirely taken off, and a free draught is permitted to the external air, which passes along a vault under ground to the ash-hole, through the holes in the circular grate or plate, betwixt the crucibles, and through the upper mouth along with the smoke and flame into an area where the workmen stand, which is covered with a large dome or chimney through which the smoke and air ascend. When the heat is to be diminished, the mouth of the furnace is to be closed with the lid, through the holes in which the air, smoke, and flame pass. The crucibles are

Although zinc be only a semi-metal, and consequently not ductile, and although metallic mixtures be generally less ductile than the pure metals of which they are composed, zinc seems to be an exception to this rule in its combination with copper; for it has the property of uniting with that metal in a large proportion, as of a third, or a fourth, without sensibly diminishing the ductility of the copper. But as this property is quite peculiar to zinc, it is evident that it is necessary, in order to make good brass, that the copper and zinc be, each of them, in their greatest purity.

If such zinc as is procured in the smelting of ores be melted with copper, as in some mixtures commonly used, we might indeed obtain a very fine-colored brass, but it would be brittle and unmalleable. It would only be a mixture of that kind called *tombacs*, because this zinc is never very pure. See ZINC.

This inconvenience is avoided in making brass, by a kind of cementation with the ore of zinc, which is lapis calaminaris. This process is performed in the following manner.

A cement, composed of one part and a half of good lapis calaminaris and powder of charcoal triturated together, and moistened with water, is put into an earthen pot or crucible. Then one part of very pure copper beat into

to be kept red-hot during eight or ten hours, and in some places much longer, even several days, according to the quality of the calamine; during which time the zinc rises in vapor from the calamine, unites with the copper, and renders that metal fusible by considerably less heat than it is alone. To render the metal very fluid, that it may flow into one uniform mass at the bottom, the fire is to be increased a little before the crucibles are taken out for the pouring of the fluid metal into moulds. From sixty pounds of good calamine and forty pounds of copper, sixty pounds of brass may by this process be obtained, notwithstanding that a considerable quantity of zinc is burnt and dissipated during the operation; as we may learn from the blue flame round the mouths of the crucibles and furnaces, from the flowers of zinc which adhere to the inner sides of the furnace, and from the blue color communicated to the crucibles. The quantity of brass obtained has been considerably augmented since the introduction of the method now commonly practised of using granulated copper, by which a larger surface of this metal is exposed to the vapor of the zinc, and consequently less of that vapor escapes. For the granulation of the copper, a cylindrical wooden reservoir is made, four or five feet deep, in which a circular brass or copper

bottom may be raised or lowered, by means of a chain. This reservoir is covered with a copper lid, in the middle of which is a hole half a foot in diameter, intended to receive an iron ladle pierced with holes, and coated with clay. The reservoir being filled with water, the melted copper is poured through the holes in the ladle into the water; where it is broken by its fall into smaller drops or grains, is rendered solid by the cold water, and is collected in the moveable bottom, which is afterwards to be raised by the annexed chain, that the granulated copper may be taken out.—The above is the process generally employed for making brass. But to make the finer and more malleable kinds of brass, besides the choice of pure calamine and pure copper, some manufacturers cement the brass a second time with calamine and charcoal, and sometimes add to it old brass, by which the new is said to be meliorated.

Brass is brittle when hot, but is so ductile when cold that it may be drawn into very fine wire. Its beautiful color, its hardness, its malleability, its fusibility, by which it may be easily cast into moulds, and its quality of being less subject to rust or verdigris than copper, render it fit for the fabrication of many utensils.

plates,



plates, is placed over the cement, and the whole is covered with charcoal dust. The crucible is then closed, and is heated only enough to make it gradually become red. When the flame of the coals has acquired a cupreous color, an iron rod is introduced into the crucible, to try if the copper be melted under the cementing powder. If that be the case, the action of the fire is moderated, and in a few minutes the crucible is taken out.

When it is cooled, the copper is found to have become yellow, and to have received an augmentation of a fourth, and sometimes of a third of its weight, and is nevertheless very malleable.

This process is, as we see, a kind of cementation, in which the zinc is raised from its ore in vapors, and combines with the copper. This method is advantageous, principally because the other metallic matters, and particularly the iron, from which lapis calaminaris is seldom free, do not rise in vapors, and consequently cannot combine with the copper.

In order to effect this purpose more certainly, the cementing powder may be mixed up with clay into a paste; which being put in the bottom of the crucible, is to be covered with plates of copper and charcoal powder, proceeding as is directed above. The copper, penetrated by the vapors of the zinc which pass through the paste, melts upon the surface of the paste, and does not mix with the other metals, which always alters the color and ductility of the brass. These processes are from M. Cramer.

The advantages of converting copper into brass are, that its weight is augmented one fourth part; that its color is changed to one more agreeable, as it approaches the color of gold; that it is more fusible; and lastly, that it is less subject to rust, because zinc is less susceptible than copper of being altered by the action of air and of water.

Although zinc be fixed to a certain degree in brass by the adhesion it contracts with the copper, yet when brass is melted and exposed to a violent fire during a certain time, the zinc dissipates in vapors, and even flames away, if the heat be strong enough; and if the heat lasts long enough, all the zinc will be evaporated and destroyed, so that what remains is copper.

Copper, or copper converted into brass, or in any other form, but particularly when penetrated by any salts and reduced into verdigrise, produces always, when taken internally, the most troublesome consequences, and becomes a poison. For this reason it is dangerous to use copper utensils and vessels for the purpose of cookery, and in many places they begin to be disused.

For the same reason also, none of the preparations of this metal are ever employed medicinally by prudent physicians. It appears, however, to enter into the composition of a remedy much used, the *Lilly of Paracelsus*, or *Tincture of Metals*: but in fact, it is certain that the spirit of wine, employed for the preparation of this medicine, dissolves nothing of the calx of copper, or of the other calxes of metallic substances digested in it. Mr. Beaumé convinced himself of this fact by a most accurate examination of the *Lilly of Paracelsus*.

The best remedies for persons poisoned by verdigrise are, mild, watery, mucilaginous, and oily drinks, given quickly and copiously, which ought to be immediately succeeded by evacnants to carry off the poison as fast as is possible.

The use of copper then in medicine is confined to external applications. It is stimulant, tonic, and deterfive. Verdigrise enters into the unguentum Egyptianum, into several plasters, the collyrium of Lanfranc, and the green balsam of Metz. A blue water for the eyes is made with copper and sal ammoniac, which is called *Celestial water*.

CXX. B R E A D. The grains of all vegetables are almost entirely composed of substances very proper for the nourishment of animals; and amongst grains those which contain a farinaceous matter are the most agreeable and most nutritive.

Man, who appears to be designed by nature to eat of all substances which are capable of nourishing him, and still more of vegetables than animals, has, from time immemorial, and in all parts of the earth, used farinaceous grains as the principal basis of his food: but as these grains cannot be without difficulty eaten by men in their natural state, this active and intelligent animal has gradually found means not only to extract the farinaceous part, that is, the only nutritive part of these grains, but also to prepare it so that it becomes a very agreeable and wholesome aliment, such as the bread we now generally eat.

Nothing appears so easy at first sight as to grind corn, to make a paste with the flour and water, and to bake this paste in an oven. They who are accustomed to enjoy the advantages of the finest human inventions, without reflecting on the labor it has cost to compleat them, think all these operations common and trivial. However, it appears very certain, that for a long time men no otherwise prepared their corn than by boiling and forming compact, viscous cakes, not very agreeable to the taste, and of difficult digestion, before they were able to make bread of good taste and quality, as we have now. It was necessary to invent and compleat ingenious machines for grinding corn, and separating the pure flour with little trouble and labor, and that inquiries, or rather some happy chance, which some observing person availed himself of, should discover that flour mixed with a certain quantity of water is susceptible of a fermentation, which almost entirely destroys its viscosity, heightens its taste, and renders it proper to make a light bread, very agreeable to the taste, and of easy digestion.

This essential operation, on which the good quality of bread depends, is entirely of the province of chemistry. It would add to the honour of the ancient cultivators of chemistry, to attribute to them so useful and important a discovery; but unhappily it is too probable that they had no share in it. The ancient chemists were engaged in other pursuits than that of bread and other common objects. They hoped to make gold; and what is bread in comparison with gold?

However that be, to the fortunate invention of raising the paste before baking we owe the perfection of the art of making bread. This operation consists in keeping some paste or dough, till by a peculiar spirituous fermentation it swells, rarefies, and acquires a finell and taste quick, pungent, spirituous, somewhat sour, and rather disagreeable. This fermented dough is well worked with some fresh dough, which is by that mixture, and moderate heat, disposed to a similar, but less advanced fermentation than that above mentioned. By this fermentation the dough is attenuated and divided, air is introduced into it, which

which being incapable of disengaging itself from the tenacious and solid paste, forms in it small cavities, raises and swells it: hence the small quantity of fermented paste which disposes the rest to ferment, is called *leaven*, from the French word *lever*, signifying to raise.

When the dough is thus raised, it is in a proper state to be put into the oven, where, while it is baked, it dilates itself still more by the rarefaction of the air, and of the spirituous substance it contains, and it forms a bread full of eyes or cavities, consequently light, and entirely different from the heavy, compact, viscous, and indigested masses made by baking unfermented dough,

The invention of beer, or wine of grains, furnishes a new matter useful in the making of bread. This matter is the froth which forms upon the surface of these liquors during fermentation. When it is mixed with dough, it raises it better and more quickly than ordinary leaven. It is called *yeast* or *barm*. By means of this the finest, lightest bread is made. It often happens that bread made with leaven dough has a sourish and not agreeable taste, which may proceed from too great a quantity of leaven, or from leaven in which the fermentation has advanced too far. This inconvenience does not happen to bread made with yeast; because the fermentation of this substance is not too far advanced, or because more attention is given to that finer bread.

It may be asked, why, since dough is capable of fermenting spontaneously and singly, as we see from the leaven, a substance is added to dispose it to ferment. The true reason is, that all the parts of a fermenting substance do not ferment at the same time, nor to the same degree; so that some parts of this substance have finished their fermentation while others have not yet begun. The fermentable liquors which contain much sugar, as hydromel, and must of wines, give proofs of this truth; for, after these liquors have become very vinous, they have still very distinctly a saccharine taste: but all saccharine matter is still susceptible of fermentation; and, in fact, if vinous hydromel, or must, or even new beer, be distilled, so that all their ardent spirit shall be separated, and the residuums diluted with water, we shall see a second fermentation take place, and a new quantity of ardent spirit formed.

The same thing precisely happens to dough, and still more sensibly, from its viscosity and want of fluidity; so that if it be left to ferment alone, and without the help of leaven, as the fermentation proceeds very slowly and successively, the parts which ferment first will have become sour and vapid before all the rest be sufficiently attenuated and changed, by which the bread will acquire a disagreeable taste.

A mixture of a small quantity of leaven with dough effectually prevents this inconvenience; because the effect of this leaven, and of all fermenting substances, is to dispose to a similar fermentation all matters capable of it, with which it is mixed; or rather, by means of leaven, the fermentation of all the parts of such substances is effected more nearly at the same time.

Bread well raised and baked differs from unfermented bread, not only in being less compact, lighter, and of a more agreeable taste, but also in being more easily miscible with water, with which it does not form a viscous mass, which circumstance is of great importance in digestion.

**CXXI. BRONZE.** Bronze is a compound of copper and tin, to which sometimes other metallic substances, particularly zinc, are added.

Bronze is brittle, hard, and sonorous. It is employed for various uses, as for making bells, cannons, and statues; and the proportions of the component metals are varied to suit the several uses to which it is applied.

The compound of copper and tin has a greater than the intermediate specific gravity. Two ounces of a metal composed of four-fifths of pure copper, and one fifth of pure tin have seven grains and the tenth of a grain more of specific gravity, than the same quantities of these two metals not alloyed have. (*k*) This proves that in the union of copper and tin there is a penetration of parts; that is, that one metal enters into the pores of the other. Perhaps even this effect is reciprocal.

Many chemists, and particularly Glauber and Becker, have a long time ago remarked, that the specific gravities of metallic alloys differed more or less from what they ought to be, if there were no penetration, and that sometimes the effect is contrary. But lately this matter has been treated with more precision. Several good chemists, such as Eisporn, Hahn, Kraft, and Gellert, have given results of well conducted experiments on this subject. See Gellert's *Metallurgic Chemistry*. See the words ALLAY, GRAVITY (SPECIFIC).

Mr. Tillet, member of the Royal Academy of Sciences, observes, in his Memoir concerning the ductility of metals, that when the mixture of copper with tin is made in the proportions above-mentioned, the color of the copper is entirely annulled and covered by that of the tin, although the quantity of copper be four times the quantity of tin. This singular effect cannot be understood without admitting a total change in the size and disposition of the pores of the compound metal; which consequently is a new proof of the reciprocal penetration of the two metals.

As tin is less sensible to the action of salts, of moisture, and of the air, than copper, it is also less liable to rust: hence bronze is less apt to be covered with verdigrise than pure copper is. This is one reason why this alloy is used for cannons, statues, and works exposed to the air and weather.

The greater fusibility of bronze than of copper is also an advantageous property, and much facilitates the casting of large works, as statues, bells, and cannon.

Lastly, a phenomenon worthy of attention is, that tin, though greatly softer and less sonorous than copper, nevertheless renders this metal, by being alloyed with it in a proper proportion, more hard and more sonorous: hence this alloy is used for bells.

The operation by which large works of bronze are cast is sufficiently simple. For this purpose a brick furnace is used, nearly of the shape of an oven for baking bread. The floor of this furnace is concave, and consists of a composition of sand and clay. In this hollow floor the metals to be fused are put. The furnace has three openings.

The first is a lateral mouth, at which enters the flame of wood placed in a second furnace on one side of the first: the second opening is a chimney placed on the side opposite to the mouth, by means of which the flame is drawn over

(*k*) The author means, I suppose, that a metallic mass, weighing two ounces, composed of four-fifths of copper and one fifth part of tin, weighs, in water,  $\frac{7}{10}$  grains more than the same quantities of these two metals would together weigh, in water, if not alloyed.

the metal. The third opening is a hole which is opened and shut at pleasure, through which the inner part of the furnace may be occasionally inspected, that the state of the metal may be observed. When the metal is in the state required, a fourth opening is then unclosed, communicating with the hollow floor, and through which the melted metal flows by channels into the moulds prepared to receive it.

CXXII. BRYONY. (l)

CXXIII. BURDOCK. (m)

CXXIV. BUTTER. Butter is the fat, oily, and inflammable part of milk. This kind of oil is naturally distributed through all the substances of the milk, in very small particles, which are interposed betwixt the caseous and serous parts, amongst which it keeps itself suspended by a slight adhesion, but without being dissolved. It is in the same state in which oil is, in emulsions; hence the same whiteness of milk and emulsions, and hence by rest the oily parts separate from both these liquors to the surface, and form a cream. See EMULSION.

When butter is in the state of cream, its proper oily parts are not yet sufficiently united together to form a homogeneous mass. They are still half-separated by the interposition of a pretty large quantity of caseous and serous particles. The butter is completely formed by pressing out these heterogeneous parts by means of continued percussion. It then becomes an uniform soft mass.

Fresh butter, which has undergone no change, has scarcely any smell; its taste is mild and agreeable; it melts with a weak heat, and none of its principles are disengaged by the heat of boiling water. These properties, together with that of not inflaming but with a heat greater than that of boiling water, capable of decomposing it, and reducing it to vapors, prove that the oily part of butter is of the nature of the mild, fat, and fixed oils obtained from many vegetable substances by expression. See OILS (SWEET EXPRESSION).

The half fluid consistence of butter, as of most other concrete oily matters, is caused by a considerable quantity of acid, united with the oily part: but this acid is so well combined, that it is not sensible while the butter is fresh, and has undergone no change; but when it grows old, and undergoes some kind of fermentation, then the acid is disengaged more and more; and this is the cause that butter, like oils of the same kind, becomes rancid by age.

The acid of butter is more quickly and sensibly disengaged by fire. If butter be exposed to a degree of fire strong enough to make it smoke, vapors are exhaled from it insupportably acrid, which draws tears from the eyes, and excites coughing, as may be daily observed in kitchens. These vapors are nothing else than the disengaged acid. The remaining part of the butter after this operation has a strong taste, very different from its former mildness; because the part of the acid which is not exhaled is become sensible and half-disengaged by

(l) BAYON. From two ounces of this plant Neuman obtained by water ten drams of gummy extract, and from the same quantity he obtained by spirit two drams two scruples and a half of resinous extract.

(m) BURDOCK ROOT. From 16 drams of this root Neuman extracted by water 7 drams 52 grains, and from an equal quantity of it by spirit he extracted 5 drams and 40 grains.

the action of the fire. The same thing precisely happens when butter is distilled in a retort.

To decompose butter by distillation, a much greater heat than that of boiling water must be applied to it: acid vapors are then raised of considerable volatility and acrimony. These vapors are accompanied with a small portion of oil, which being that part which is mostly deprived of its acid, does not congeal; then a second oil of a red color passes, which congeals when cold, and which becomes more and more thick as the distillation advances. Lastly, a small quantity of charry matter remains in the retort, which in an open fire can be scarcely burnt entirely, and reduced to ashes.

If the congealed oil in the receiver be again distilled, more acid and fluid oil are obtained. Thus the whole of it may be reduced into acid and fluid oil by repeated distillations.

The acid obtained is accompanied with phlegm, particularly at first, and with a portion of oil united with it, which it renders soluble in water, and to which it partly owes its volatility. It is owing to this oil that the acid has the empyreumatic smell of burnt butter.

There are many essential remarks to be made upon this analysis of butter by distillation; because it presents exactly the same phenomena as the analysis of all other concrete oily matters of the same kind, such as wax, suet, cacao, butter, sperma-ceti, and may be considered as a specimen of the decomposition of all these matters.

First, it is necessary that these distillations should be made slowly, and with the precise degree of heat necessary for continuing a moderate distillation; because when the distillation is too much hurried, the acid has not time to separate itself, and the concrete oily matter passes almost entirely into the receiver without suffering any decomposition: but whatever management be employed, a considerable part of this half-decomposed matter always passes, which must be subjected to future distillations in order to reduce it to fluid oil.

Secondly, when the distillation is too much hurried, the acid passes in white sensible vapors from the quantity of oil united with it. For the same reason, towards the end of the distillation, when the fire must be raised, the acid always passes in this form of white sensible vapors.

Thirdly, at each distillation, made of butter, or of its congealed oil, there is always a portion of oil entirely decomposed, and thus the quantity continually diminishes, and sensibly.

This quantity of entirely decomposed oil is proportionable to the quantities of phlegm, acid, charry residuum, or earthy phlogisticated matter, which are obtained at each distillation, and are the proximate principles of the oil. This remark is applicable to the distillation of any oil. *See OIL.*

We ought also to observe in general upon this analysis of butter, that this matter, although derived from animal bodies, does not yield a particle of volatile alkali; neither does the fat of animals; which proves that these substances are not assimilated to other animal substances, all which, when decomposed, furnish volatile alkali, without excepting the oils obtained from these substances.

Butter is constantly used in food, from its agreeable taste; but to be wholesome, it must be very fresh, and free from rancidity, and also not fried or burnt;

burnt ; otherwise its acrid and even caustic acid being disengaged, disorders digestion, renders it difficult and painful, excites acrid, empyreumatic belchings, and lastly, introduces much acrimony into the blood. Some persons have to delicate stomachs, that they are even affected with these inconveniences by fresh butter and by milk. See MILK. This observation is also applicable to oil, to fat, to chocolate, and in general to all oleaginous matters.

CXXV. BUTTER of ANTIMONY. Butter of antimony, called by some chemists the *glacial oil of antimony*, is composed of marine acid united with the reguline part of antimony.

This is one of the combinations which cannot be made directly ; that is, by the application of pure and liquid marine acid to the regulus of antimony ; for in this manner the marine acid, however strong, dissolves none, or almost none, of the regulus : but when the acid is in its highest degree of concentration, reduced almost to dryness, as it is in several combinations, and when the body to which it is united has a less strong affinity to it than the regulus of antimony has, then it quits that body to unite with the regulus, and forms the butter of antimony.

Marine acid united with mercury has all the above-mentioned conditions ; wherefore butter of antimony may be made by mixing together corrosive sublimate and regulus of antimony, both well powdered, and by applying a certain heat and distillation.

Lémeri, the most exact of the operators who have written, says, that the best proportion of corrosive sublimate and regulus of antimony is sixteen parts of the former to six parts of the latter. He observes, that this mixture frequently becomes very hot, some time after it has been made. This heat proceeds from the re-action of the two matters upon each other even without fire.

To proceed to the distillation of butter of antimony : this mixture must be put in a retort of convenient size, the neck of which ought to be large and short ; this retort is to be placed in a furnace with a sand-bath ; a receiver is to be luted, and the distillation is to be carried on at first by a gentle fire, which is to be increased as more heat becomes necessary to continue the operation ; a heavy liquor rises, which congeals in the receiver when it cools : this is the butter of antimony. The operation is stopped when it appears that it cannot be continued without a great increase of heat, by which fluid mercury would be distilled instead of butter of antimony.

If then it be required to obtain this mercury, which is a very pure mercury, revived from corrosive sublimate, before the fire is increased, it is proper to remove the receiver, and apply another containing some water.

It is evident, that as the marine acid only unites with the regulus of antimony by disengaging itself from the mercury of the corrosive sublimate, this latter metal ought to appear in its proper fluid form ; but as it is less volatile than the butter of antimony, it does not rise till this has passed, and the fire be increased.

Butter of antimony may also be made by using antimony itself instead of its regulus ; because the acid of corrosive sublimate attacks as easily the regulus of antimony in the antimony itself, although it be there united with sulphur, as when it is pure : but it is evident, that in this case more antimony must be used, than the requisite quantity of regulus in the preceding operation. Lemeri

observes, that twelve parts of antimony are necessary for sixteen parts of corrosive sublimate.

When butter of antimony is made by this latter method, it more readily congeals, and is more solid than when made with the regulus.

Mr. Baron, in his notes on Lameri's Chemistry, says, that this proceeds from the greater quantity of acid contained in the butter made with the regulus than in that made with antimony. This matter would require a particular examination.

However that may be, a part of this butter made with antimony always congeals in the neck of the retort, and is frequently accumulated there in sufficient quantity to block up the passage, by which means the confined vapours may occasion an explosion. This inconvenience is prevented by applying a hot-coal near the neck of the retort, by which the butter is melted, and made to flow into the receiver.

It is evident, that when the butter of antimony is made with antimony, if the distillation be continued after the butter has passed, we shall not then obtain fluid mercury, but a combination of mercury with the sulphur of the antimony, that is, a cinnabar will be sublimed. This is called the *cinnabar of antimony*. See MERCURY, SULPHUR, and CINNABAR.

This cinnabar makes its appearance towards the end of the operation by red vapours. As soon as these are seen, the receiver ought to be changed.

The butter of antimony made by either of these operations, especially by the latter, is generally rendered more or less impure by some fluid mercury, or by some cinnabar, which are raised along with it: but it is easily purified from these extraneous substances by a second distillation with a gentle heat, when it becomes very white and pure. This second distillation, as all other repeated distillations and sublimations for the purifying of substances, is called *rectification*.

Some sublimate, mercurial panacea, and white precipitate, are also mercurial combinations with marine acid; and, like the corrosive sublimate, are capable of being decomposed by means of regulus of antimony, and of forming with it this butter of antimony. But Lameri observes, that these butters are less volatile than that made with corrosive sublimate; undoubtedly because these mercurial compounds contain less marine acid.

Lastly, butter of antimony may be made with *luna cornea*, which is a combination of silver with very concentrated marine acid, which is nearly in the same state as it is in corrosive sublimate, (see LUNA CORNEA); because the marine acid has less affinity with silver than with regulus of antimony. This butter is called the *lunar butter of antimony*.

Butter of antimony then contains a very concentrated marine acid, which is so intimately engaged with the regulus of antimony as to lose all its properties; hence we may account for the property which the butter of antimony has of attracting moisture from air, and for its volatility; for it is strongly corrosive, and is applied, like lapis infernalis, to ulcers and to cancerous tumours. See CAUTERY.

This metallic salt has been called *butter*, from its consistence, which is nearly the same as that of butter, and from the facility with which it melts with a very gentle heat.



Butter of antimony ought to be classed among the salts which are at once crystallizable and deliquescent; for however confused the mass seems after distillation, it is in fact a heap of very small crystals.

By the operation of butter of antimony, and its properties, several essential properties of the marine acid and of regulus of antimony are discovered.

First, although the marine acid has a great affinity with this semimetal, it cannot dissolve it, but when highly concentrated. This phenomenon is analogous to those presented by the marine acid with mercury and with silver, to both which it has a great affinity, but which it cannot dissolve unless it be very highly concentrated, or applied to them when their aggregation is broken; as we see by the operations of making *white precipitate*, *corrosive sublimate*, *luna cornea*, and of the *concentration & parting*. See all these words.

Secondly, the property which the butter of antimony has of not being decomposed by fire alone; as the metallic salts are which contain the vitriol & nitrous acids, depends on the great adhesion which the marine acid contracts with the regulus of antimony, as it generally does with other metallic matters, and on its property of volatilizing them, or carrying them along with it in distillation; which we see happens in corrosive sublimate, luna cornea, smoking spirit of Libavius, and many other chemical operations, in which the most fixed metals are carried off by marine acid.

Thirdly, the butter of antimony is by the affusion of water changed in its nature, or rather is divided into two parts, one of which is perfectly dissolved by the water and another part is precipitated, being insoluble by water. The dissolved part contains its greatest possible quantity of acid, and the precipitated part contains the least possible quantity of acid. This latter part, when well washed, is called *mercurius vitæ*, or *powder of algaroth*. See POWDER of ALGAROTH.

Mr Beaumé pretends, that the powder of algaroth is improperly said to contain the least possible quantity of acid, since, by a sufficient lavation, he has been able to deprive it of every vestige of an acid.

Butter of antimony is soluble in nitrous acid, and this solution is made with great violence: afterwards, by evaporation of the acids, a white calx of antimony is formed, called *Bexoar mineral*. See that word.

CXXVI. BUTTER of ARSENIC. Butter of arsenic, called also *corrosive oil of arsenic*, is a combination of marine acid with arsenic. This combination is made by a process similar to that of the butter of antimony. According to LEMERY, equal parts of butter of arsenic and corrosive sublimate ought to be pulverised, well mixed, and distilled together; by which a butyaceous liquor is obtained similar to butter of antimony in its external appearance.

When the distillation cannot be continued without considerably increasing the fire, the receiver ought to be taken off, and another receiver, in which there is some water, adapted to the retort; then, upon raising the fire, fluid mercury may be obtained. See BUTTER of ANTIMONY.

This experiment shews, that the affinity of marine acid to arsenic is greater than to mercury. In this operation the mercury is revived from the corrosive sublimate.

It is evident that this butter of arsenic must be a most violent caustic. It ought not to be ever used, from its poisonous quality. *See ARSENIC.*

It does not appear that this combination of marine acid with arsenic has been carefully examined by any chemist.

**CXXVII. BUTTER of CACAO.** Butter of cacao is an oily, concrete, white matter, of a firmer consistence than butter, or even than suet. This substance is extracted from the kernel of a fruit called *cacao*, with which *chocolate* is made.

As the butter of cacao is a true congealed oil, it cannot be obtained without a heat sufficient to melt it. The best method is to bruise the cacao, and to boil it in water. Almost all the superabundant and uncombined oil, which this substance contains, is liquefied, and separated from the parenchyma and extractive part; and as it is lighter, it swims on the surface of the liquor in which it is left to congeal, that it may more easily be taken off. This butter is generally mixed with some broken solid bits of the cacao fruit, from which it may be purified by melting with a very gentle heat without water, in a pretty deep vessel, and by keeping it thus melted, long enough for an entire separation of the matters to take place according to the specific gravities. By this method, a very white and pure butter of cacao may be obtained.

This oily concrete substance has a very mild taste; it has no aromatic smell; it does not rise in distillation without a heat superior to that of boiling water; by distillation it is partly decomposed; lastly, it does not flame, till it is sufficiently heated to be reduced into vapors. As these are precisely the properties of mild and fat oils obtained from vegetable and animal matters by expression only, the butter of cacao must be undoubtedly ranged in this class; and as it is concrete, it is analogous to other concrete oily matters of the same nature, such as wax, fat, butter of milk, &c. also it presents the same phenomena when decomposed and attenuated by distillation. For the reason of this *See BUTTER.*

Butter of cacao has quite the same medicinal properties as all the mild expressed oils. It is emollient and blunting when not rancid; it enters into the composition of pomatums. *See OILS (SWEET EXPRESSED).*

**CXXVIII. BUTTER of WAX.** Butter of wax is nothing but half-decomposed wax; that is, wax deprived of a part of its acid by distillation. As this acid is the cause of the consistence of the oily part of wax, the reason is evident that the butter is softer than the wax itself. It has a strong smell, and, when left exposed to the air, it does not resume its consistence, in which it essentially differs from resinous matters. *See WAX.*

**CXXIX. BUTTER of TIN.** *Butter of tin* is a name given by some chemists to a combination of tin with the concentrated marine acid of corrosive sublimate.

Tin, as well as the regulus of antimony, has a stronger affinity to marine acid than mercury has. If then corrosive sublimate and tin, reduced to small parts, be mixed together, these two substances will act upon each other even without the application of heat, so that in time the mixture becomes moist, and attracts the humidity of the air. If these substances be distilled together immediately after their mixture, the corrosive sublimate is much more quickly decomposed.

decomposed by the tin; the marine acid quits the mercury to unite with the tin, the greatest part of which it carries off along with it. In this distillation a kind of *marine salt with basis of tin* passes over. Part of this combination is in form of a liquor which smokes continually, even when cold. This is called the *smoking spirit of Libavius*. Another part is raised in a concrete form, which more particularly deserves the appellation of *butter of tin*, although it seems that several chemists give this name indifferently to the liquor or concrete matter, or to both of them at the same time. See SPIRIT (SMOKING) of LIBAVIUS.

CXXX. B U T T O N. By the word *button* is meant the metal which is collected generally in a roundish mass at the bottom of a crucible after fusion, or which remains in the cupels after cupellation.

CXXXI.

## C.

CXXXI. **CADMI A.** The name of *Cadmia*, or *Calamine*, is given to several different substances. What is called the *Cadmia of the furnaces* is a matter which is sublimed when ores containing zinc, like those of Rammelsberg, are smelted. This cadmia consists of the flowers of zinc sublimed during the fusion, and adhering to the inner surfaces of the walls of furnaces, where they suffer a semi-fusion, and therefore acquire some solubility. So great a quantity of these are collected, that they form very thick strata, which must be frequently taken off. The name of *Calmia of furnaces*, has also been given to all the foots and metallic sublimate formed by melting in the great, although there certainly are great differences in the matters. See *SMEETING of ORES*.

Several authors call *Native* or *Fossil Cadmia*, a sort of stony mineral, containing zinc, iron, and sometimes other substances. It is of a yellow or reddish colour, and is also called *Calamy*, *Calamine*, or *lapis calaminaris*. Both this mineral and the *Cadmia of Furnaces* are used for the preparation of brass. See *BRASS*.

Lastly, some chemists have given the name of *Fossil Cadmia* to a mineral containing arsenic, frequently bismuth, silver, and particularly the semi-metal, the calx of which being melted with vitrifiable matters, forms a beautiful blue glass. This mineral is better known by the name *Cobalt*, which only ought to be given to it, to avoid the confusion attending the application of the same name to different substances. See *COBALT*.

CXXXII. **CALAMINI.** See *CADMI A.*, and *ORES of ZINC*.

CXXXIII. **CALAMUS AROMATICUS** (n).

CXXXIV. **CALCINATION.** The calcination of a body is, properly speaking, the exposing of it to the action of fire, to produce some change upon it.

The principal effects of fire in chemical operations are to carry off the volatile principles, and to separate them from the fixed, or to occasion the combustion of inflammable matters. Hence it follows that bodies are calcined either to

(n) **CALAMUS AROMATICUS.** The root of this plant has an agreeable flavour, and peculiar taste, both which are caused by an essential oil, of which two scruples were obtained by distillation from 26 ounces of the dry root. *Neuman*.

deprive

deprive them of some volatile principle, or to destroy their inflammable principle, and sometimes for both of these purposes.

We have examples of the first kind of calcination, in exposing calcareous earths and stones to the fire, to convert them into quicklime, which is effected by the entire evaporation of the watery principle contained in this kind of earth. See QUICKLIME.

The calcination of *Gypsum*, of *Alum*, of *Borax*, and of several other *Salts*, by fire, which deprives them of the water necessary for their crystallization; the roasting of minerals, by which the fire carries off the sulphur, arsenic, and other volatile contents; ought to be referred to the first kind of calcination.

We have an example of the second kind of calcination, by exposing imperfect metals to fire; by which they lose their inflammable principle, their form, and metallic properties, and are changed into earthy matters called *Metallic Calxes*.

It is necessary to observe, that this second calcination differs essentially from the first, as the changes produced by it upon imperfect metals are not effected by evaporation, but by decomposition and destruction of their phlogiston. It is therefore a *combustion*, and not a *volatilisation* of their inflammable principle.

Hence it follows, that the first kind of calcination may succeed without the contact of air and in close vessels, although it is more quick and complete in open vessels, from a property of air, by which it greatly accelerates the evaporation of volatile bodies. See AIR. But as the second kind of calcination is a true combustion, like that of all inflammable bodies, it requires all the conditions necessary for combustion, and particularly the free access of air. See COMBUSTION, and CALXES (METALLIC).

There are many bodies, in the calcination of which an evaporation of volatile parts happens, and also a destruction or deprivation of their inflammable principle, although without any sensible combustion of this latter. Such particularly are all combinations of imperfect metallic matters with vitriolic and nitrous acids: when these bodies are exposed to fire, their acid evaporates, and at the same time carries off with it their inflammable principle. We have examples of this kind of calcination in exposing to fire *Martial Vitriol* and *Bezoard Mineral*.

As vitriolic acid, and still more nitrous acid, deprive the imperfect metals of more or less of their phlogiston even without fire, several of these metals, particularly iron, copper, tin, regulus of antimony, are reduced, after they have been dissolved in these acids, to a state similar to that of calcination with access of air; that is to say, they become earths, not possessed of metallic properties, which they cannot resume without the addition of phlogiston. Hence most chemists consider acids as capable of calcining these metals, and they accordingly call earths of metals which have been dephlogisticated by acids, without fire, *Calxes*.

Lastly, nitrous acid, when engaged in a fixed alkali, that is, nitre having the property of inflaming when applied to a combustible substance with a red heat, and of making the phlogiston of these bodies burn, becomes a very powerful agent for the calcination of many substances, and particularly of imperfect metals and starchy matters. See NITRE. We have a very good example of this kind of calcination in the preparation of diaphoretic antimony.

This calcination of metals by nitre is effected partly by a dephlogistication similar to that by nitrous acid in humid solutions, and partly by combustion: which does not hinder it from succeeding without access of air, and in close vessels, from the peculiar property of nitre in this respect. *See* NITRE.

It is proper to observe, that certain preparations of gold and silver are improperly called calxes, because they are not truly calcined, no method being known by which they can be deprived of their phlogiston. *See* GOLD, SILVER, and METALS (PERFECT).

What is improperly called *Calx of Gold*, is nothing but gold reduced into very fine particles, either by amalgamation with mercury, or by its separation from other solvents. Most of these improper names, found in such numbers in chemistry, proceed from the ignorance of ancient chemists, and still more of alchemists, who all believed, for example, that they had processes for decomposing and calcining gold. Nothing is more equivocal than the pretended calcinations of perfect metals. We cannot, however, affirm its impossibility. Some facts even seem to make it probable; such as the destruction of gold in the focus of Thirshhausen's great lens, an account of which is published by Homberg in the Memoirs of the Academy of Sciences, and the calcination of gold by long reverberation, in the manner of Isaacus Hollandus. But if the most simple and easy experiments of chemistry require frequent repetition to be sufficiently established, certainly these, which are exceedingly difficult and laborious, require great attention. *See* COMBUSTION, for some essential observations regarding the second kind of calcination.

CXXXV. CALXES of METALS. Metallic calxes are earths of metals deprived of their phlogiston, and consequently of their metallic properties.

All metallic substances, excepting gold, silver, platina and mercury, are susceptible of being deprived of their inflammable principle by several methods.

The first method is by burning their phlogiston in open air, and by a calcination, or rather a combustion similar to that of all other combustible matters. *See* CALCINATION and COMBUSTION.

The second method is by applying to metals acids capable of depriving them of their phlogiston, such as vitriolic acid, and particularly nitrous acid. This kind of calcination of metals is made in the humid way, and by solution. *See* SOLUTION.

The third method is by nitre, with which metallic matters may be detonated. This third method, which is composed of the two former, is the most efficacious and expeditious. *See* NITRE, and DETONATION of NITRE.

The earths of metals deprived of phlogiston by any of these methods have properties peculiar to each, concerning which the articles of the several metallic substances ought to be consulted; but they also have properties general and common to all. These are the following.

Not only calcined metals lose the characteristic properties of metals, but also the following changes are effected. The more perfectly metallic matters are calcined, the more they lose of their fusibility; so that very fusible substances, such as tin and regulus of antimony, are rendered by a perfect calcination, (that is, till they become very white) bodies absolutely infusible, and which may be

classed amongst those that are refractory. Hence it is proved that phlogiston is the principle of fusibility of metals.

In proportion as metallic substances lose their phlogiston, they become more fixed. This property is less sensible in metals, from their fixity, than in semi-metals, all which are very volatile when in their metallic state, and the calxes or earths of which become exceedingly fixed, as we see very evidently from the example of diaphoretic antimony, which resists the most violent fire without the least loss, and which recovers all its volatility, if it be restored to its reguline state by addition of phlogiston. This proves that phlogiston is a principle essentially volatile, and that it communicates its volatility to certain bodies with which it is combined.

Metallic earths become less soluble in acids, and particularly in nitrous acid, by being deprived of phlogiston, as we may perceive from crocus martis when well calcined, from calxes of tin, of regulus of antimony, &c. Hence we are led to conclude, that the solubility of metallic substances by acids, and particularly by nitrous acid, depends on the intervention of phlogiston: for if calxes be reduced by adding phlogiston, the metals resulting from that reduction will then recover their solubility.

What we have said concerning the general changes produced by calcination of metallic matters, upon their fusibility, their fixity, and solubility, may also be applied to their opacity, their specific gravity, in a word, to all their metallic properties, which are always diminished so much more in metallic calxes, as they are more perfectly dephlogisticated. This seems to indicate, that if an entire and perfect calcination of metallic substances could be effected, they would then have no metallic property, and perhaps they would not specifically differ from each other, and only be one and the same kind of earth. This is certain, that when the calcination of metals has been too long continued, their calxes become irreducible, or at least much more difficultly reducible; and this reduction is always made with loss, so that the quantity of metal originally calcined is never again obtained.

Although metallic calxes are essentially different from calx of stone or quicklime, they have nevertheless some similar properties, particularly those which relate to fixed and volatile alkalis. Thus, for example, fixed alkalis receive from metallic calxes the same causticity and properties as from quicklime; and volatile alkali may be separated from sal ammoniac by metallic calxes, and particularly by minium, as it may by quicklime; and it receives the same changes, that is, it becomes more penetrating, is always fluid, and cannot be reduced to a concrete state, when treated with a sufficient quantity of these matters. See QUICKLIME.

### CXXXVI. CAMOMILE (a).

(a) CAMOMILE. In the crown the flowers of camomile yield a small quantity of blue essential oil. The flowers contain also a saline substance, which being extracted by decoction in wine, precludes fluxes and mercury from nitrous acids, and their precipitates were different from luna cornea and corrosive sublimate. *Neuman*. Camomile flowers have been found by *Dr. Pringle's* experiments to possess eminently an antiseptic quality.

**CXXXVII. CAMPHOR.** Camphor is a vegetable, concrete, very volatile substance, and inflammable, as essential oils are; of a strong smell, and easily soluble in spirit of wine.

From all these properties, camphor perfectly resembles resins; but on the other side, it essentially differs from them in this, that when exposed to fire in close vessels, it is entirely sublimed without suffering any decomposition, and without leaving any residuum of coal or other matter. Although it has a strong taste, it has not the acrimony of essential oils: the most caustic alkalis do not act upon it: the vitriolic and nitrous acids dissolve it, but without effervescence, heat, inflammation, scorching, or other sensible change, even when these acids are concentrated.

Nitrous acid dissolves camphor without commotion; and the solution is clear and limpid. It is called *Oil of Camphor*. When it is mixed with too much water, the mixture becomes turbid and milky, because the acid has a stronger affinity with water than with camphor. The camphor then quits the acid, and appears in white flocks, which soon precipitate to the bottom of the containing vessel, their weight being encreased by some adhering acid. But when this acid is taken off by the water, the flocks of camphor rise to the surface, and there float. When they are compleatly washed and dried, they are found to be camphor entirely similar to what it was before this solution and precipitation. This is a manifest proof that camphor receives no change from the nitrous acid; which, however, of all acids, acts the most powerfully upon oily matter. See OILS (ESSENTIAL) and RESINS, for the resemblances and differences betwixt camphor and these substances.

It follows from what has been said concerning the properties of camphor, that this singular substance, although it has many of the essential properties of oils and resins, is not, however, comparable to any of those which are known, and forms a class apart. As, excepting its concrete state, camphor approaches more to the nature of ether, precisely by those very properties in which it differs from oils, it is to be presumed that this substance is analogous to ether, as Mr. Macquer conjectures in his Elements of Chemistry. See ETHER.

All the camphor which is sold comes from India and Japan. It is procured from a kind of laurel called *Laurus Camphorifera*, great numbers of which grow in the island Borneo. A long time this tree was believed to be the only vegetable containing camphor; but several modern chemists, and particularly Mr. Cartheuser, have discovered, that many aromatic plants, as thyme, rosemary, sage, and almost all the labiated kind, contain a substance of the nature of camphor, which may be extracted, although in very small quantities.

Camphor when first extracted from its tree is mixed with many impurities, and is then called *Rough Camphor*. The Dutch, who chiefly make a trade of it, purify it by sublimation in glass matrasses.

Camphor is used in medicine as sedative and antispasmodic. It succeeds well in many convulsions, and other nervous affections. This quality is common to it, and to all other ethereal, oily, volatile substances, such as *Ether, Sassafras, Animal oil, highly rectified Essential Oils; Mace, Clove, Opium*, and other similar substances. Hoffman has observed and commented, more than any other physician, the sedative powers of camphor. This substance is also very successfully used



used as a powerful antiseptic; and when dissolved in spirit of wine, is employed against gangrenes.

### CXXXVIII. CANTHARIDES (p).

CXXXIX. CAP. The piece which terminates the top of a melting furnace is called the *Cap*. This piece has the form of an oblong dome. In one side there is a large oval door, intended for the introduction of a considerable quantity of coal at a time, because this kind of furnace consumes a great deal, and must be quickly supplied. The upper part of the cap is terminated by a tube or chimney, which may be lengthened at pleasure by the addition of other tubes adjusted to each other. See FURNACE (MELTING).

CXL. CAPITAL. The *Capital* or *Head* is the upper part of an alembic. See ALEMBIC.

CXLI. CAPUT MORTUUM. This is a Latin name given to fixed and exhausted residuums remaining in retorts after distillations.

As these residuums are very different, according to the substances distilled, and the degree of heat employed, they ought to be specified more particularly by adding a term denoting their qualities; as, for example, we might say, *Earthy Residuum*, *Cherry Residuum*, *Saline Residuum*, &c. This method is more accurate and distinct, and is chiefly used by modern chemists.

CXLII. CARDAMOM (q).

CXLIII. CARDUUS. (r).

CXLIV. CARMINE (i).

CXLV. CARNELIAN (i).

CXLVI. CASE-HARDENING (u).

(p). CANTHARIDES. These insects contain a very acrid resinous substance, six drams and two scruples of which were extracted by spirit of wine from four ounces of cantharides. The stimulating power of cantharides is caused by this substance, and not, as some imagine, by a volatile alkali, of which they yield less by analysis than some other animal substances, and none without the action of fire. *Neuman*.

(q) CARDAMOM. An ounce of the seeds of the lesser cardamom contain about a scruple of essential oil, by which their pungency and aromatic smell are caused, with fourteen grains of resinous extract, and forty-five grains of mucilage. *Neuman*.

(r) CARDUUS BENEDICTUS. From four ounces of the leaves of this plant may be obtained about 4 1/2 drams of resinous extract by means of spirit of wine, or from the same quantity of leaves, about 6 1/2 of mucilaginous extract by means of water. In the juice of this plant, silver paper, degummed, and evaporated, forms crystals similar to sugar when formed. *Neuman*.

(i) CARMINE is a red pigment prepared

by dissolving cochineal in an alkaline liquor, and precipitating the solution by alum. It consists, therefore, of the coloring matter of cochineal adhering to the earth of alum.

(i) CARNELIAN, *Carniolus*, or *Sardus*, is a semi-transparent reddish agate. See AGATE.

(u) CASE-HARDENING of iron is a superficial conversion of that metal into steel by the ordinary method of conversion, namely, by cementation with vegetable or animal coals. This operation is generally practised upon small pieces of iron wrought into tools, and instruments, to which a superficial conversion is sufficient; and it may be performed conveniently by putting the pieces of iron to be case-hardened, together with the cement, in an iron box, which is to be closely shut and exposed to a red heat during some hours. By this cementation, a certain thickness from the surface of the iron will be converted into steel, and a proper hardness may be afterwards given by sudden extinction of the heated pieces of converted iron in a cold fluid. See STEEL.

CXLVII.

## CXLVII. CASSIA (x).

## CXLVIII. CASTOR (y).

CXLIX. CAUSTIC (COMMON). Common caustic is a fixed alkaline salt, sharpened by quick-lime, and deprived of all moisture by drying and fusion. The alkali employed for this preparation is generally potash. A lixivium is made with quick-lime, like that of the soap-boilers, called soap-leys. See LIXIVUM of SOAP BOILERS. This lixivium is to be evaporated to dryness in a copper or silver vessel. Afterwards the dry matter is to be put into a crucible, and exposed to fire till it flow like melted wax. Then it is to be poured into a bason, and quickly cut into pieces, while it is still hot and moist, and is to be speedily put into a glass bottle, well closed with a glass stopper.

An alkali thus treated is much more caustic than ordinary fixed alkali. It is also more fusible; and attracts the moisture of the air much more readily; for which reason it ought to be cut and put into bottles, while it is yet hot, otherwise it would become very soon moist.

This alkali when applied to the skin during half or three quarters of an hour, corrodes it, and forms a painful eschar, like that produced by burning. It is employed to open issues, which formerly were much used, but were afterwards almost abolished. They have since been brought again into frequent use; and justly, for they are serviceable by evacuating vicious fluids which resist other remedies. But at present common caustic is not much used for the opening of issues, because it occasions a quick and long pain. The common method at present is to make an incision with a knife, and to promote the suppuration by methods well known in surgery.

The causticity of common caustic must not be believed to proceed from a perfect drying and concentration of the alkali. This concentration does indeed augment its causticity; but we are no less certain, that independantly of that, alkalis treated with quick-lime are much more active and caustic, even when they are fluid, than any other alkalis. This is evident from the effects of the lixivium, or ley of soap-boilers, which almost instantaneously corrodes and destroys all animal matters. This causticity then is caused by some particular change produced upon alkalis fixed or volatile by quick-lime; which change probably consists in depriving them of some unctuous matter, which envelops and blunts their saline principle. See ALKALI (FIXED), ALKALI (VOLATILE), AMMONIAC SALT, SPIRIT (VOLATILE) of SAL AMMONIAC, LIXIVUM of SOAP-BOILERS.

CL. CAUSTIC (LUNAR). Lunar caustic, or *Lapis Infernalis*, is a caustic made by taking from lunar crystals all their water of crystallization by fusion.

To make the lunar caustic, crystals of silver are to be put into a Hessian crucible, which ought to be large in proportion to the quantity to be used, be-

(x) CASSIA. The fruit called *Cassia Fistularis* contains a sweet saline substance, soluble in water or in spirit of wine. *Neuman*.

(y) CASTOR. Two drams and a scruple of extract may be obtained from an ounce of castor by spirit of wine, or by water. By

distillation with water, the peculiar smell of the castor is given to the water: hence it may probably arise that it contains an essential oil. By distillation with spirit of wine, none of this peculiar smell is given to the spirit. *Neuman*.

cause

cause a considerable swelling and frothing happens in the beginning of this fusion. The crucible is to be placed in a furnace which ought to draw little air, and surrounded by a very small quantity of lighted coals, because these crystals are very fusible, and too great heat would be prejudicial to the preparation of the lunar caustic. This matter is then to be very quickly liquified. In the beginning particularly, the heat ought to be moderate, otherwise a part of the matter might flow over the crucible, and deflagrate like nitre upon the coals, by which the silver would be reduced. While the ebullition gradually diminishes, the fire is to be increased; and when the matter is brought to a perfect and tranquil fusion, it is to be cast into an iron mould previously heated and greased in its inner surface. The lunar caustic is there to be left till it is fixed and cold, and then it is to be put into a bottle with a glass stopper. The lunar caustic ought to be formed into small cylindrical pieces, like pencils, of about a line in diameter, and the surgeon who uses them puts them in a crayon or pencil case, to prevent his fingers being injured by touching them. The mould for the lunar caustic is so made as to give them that form. It consists of five or six hollow cylinders, placed vertically and parallel to each other, to which a gutter is adapted, by means of which the matter is poured into them. This mould is composed of two pieces which exactly fit each other, in each of which the same number of hollow semi-cylinders correspond to those of the other. By this disposition, when the lunar caustic is cast and cooled, it is obtained in entire cylinders, by separating the two pieces of the mould.

The lunar caustic must be poured as soon as it is in tranquil fusion, for that degree of heat is sufficient to carry off its acid, which may be observed to dissipate in fumes; and consequently, if it was left in the fire long after it is thus fused, it would lose some of its causticity, which it entirely owes to this acid.

The operation for lunar caustic shews two remarkable phenomena. The first is the black color assumed by the crystals of silver thus fused. I believe this color proceeds from a part of the phlogiston of the nitrous acid, which attaches itself to the silver superficially, and which always gives a black color to this and other white metals, such as mercury, lead, and bismuth, when it is thus united to them.

The other remarkable phenomenon is a certain symmetry of arrangement, or crystallization, which lunar caustic takes when it cools and becomes solid. If a pencil of lunar caustic be broken into pieces, its inner substance may be observed to be composed of needles or radii passing from the circumference to the center, much like the inside of the round ferruginous and sulphureous pyrites. This phenomenon is common to all bodies of a certain degree of simplicity of composition, which pass without agitation from a liquid to a solid state, and is a species of crystallization. Perhaps the same phenomenon occurs in many other neutral salts in which it has not yet been remarked. See CRYSTALLIZATION.

Lunar caustic ought to be made with tested silver. If silver alloyed with copper be used, the crystals of silver ought to be well drained upon brown paper, by which they will be freed from the solution of copper, and will become white. This solution of copper in nitrous acid when dried is also caustic, but less so than lunar caustic. It also has the inconvenience of becoming moist in the air. See SILVER, CAUSTICITY, and CRYSTALS of SILVER.

**CLL. CAUSTICITY.** By this word is denoted a quality belonging to several substances, by the acrimony of which the parts of living animals may be corroded, and destroyed. Bodies which have this quality, when taken internally are true poisons. The causticity of some of these, as of *arsenic*, is so deadly, that even their external use is proscribed by prudent physicians.

Several others, as *nitrous acid*, *lapis infernalis*, or *lunar caustic*, *common caustic*, *butter of antimony*, are daily and successfully used to consume excrescences, to destroy fungous flesh, to open issues, &c. They succeed very well when properly employed, and skilfully managed.

The causticity of bodies depends entirely on the state of the saline, and chiefly of the acid matters which they contain. When these acids happen to be at the same time much concentrated, and slightly attached to the matters with which they are combined, they are then capable of acting, and are corrosive and caustic. Thus fixed and volatile alkalis, although they are themselves caustic, become much more so by being treated with quicklime, because this substance deprives them of much fat or inflammable matter, which binds and restrains the action of their saline principle. (z) By this treatment then, the saline principle is more disengaged, and rendered more capable of action. Also, all combinations of metallic matters with acids, form salts more or less corrosive, because these acids are deprived of all their superabundant water, and are besides but imperfectly saturated by the metallic matters.

Nevertheless, some other circumstance is necessary to constitute the causticity of these saline metallic matters. For the same quantity of marine acid, which when pure and diluted with a certain quantity of water, should be incapable of producing any harm, shall however produce all the effects of a corrosive poison when it is united with mercury in *corrosive sublimate*, although this sublimate shall be dissolved in so much water, that its causticity cannot be attributed to the concentration of its acid.

This effect is attributed by some chemists to the great weight of the metallic parts with which the acid is united. This opinion is very probable, since the causticity is nothing but its dissolving power, or its disposition to combine with other bodies; and this disposition is nothing else than attraction, which is one and the same thing as weight or gravitation.

**CLXI. C A W K.** (a)

**CLXII. C E M E N T.** All those powders and pastes are called *cements*, with which any body is surrounded in pots or crucibles, and which are capable, by help of fire, of producing changes upon that body. Hence the expressions *to cement*, and *cementation*.

The principal cements are the *royal cement*, which is used to separate silver from gold in the operation called *Consolidated Parting*, *the PARTING*

(z) The substance which quicklime takes from alkaline salts, by which the dissolving power of these salts is encreased, is fixable air. *See AIR (Fixable).*

(a) C A W K is a white, very dense, heavy substance, un溶uble in acids, and fusible by fire. It is generally found in or near lead-mines. If an ounce or two ounces of caw

be thrown red-hot upon fifteen ounces of melted antimony, and the mass continued about two minutes, a regular melting fifteen ounces will be observed, and will be white. *See Part. from. Diss. 178.* This experiment Dr. Lavoisier has frequently repeated with success.

TRATED) the cement for converting iron into steel (*see* STEEL); the cement for converting certain glass into porcelain (*see* GLASS and PORCELAIN); the cement for converting copper into brass, *see* BRASS.

Cements may be made of many various kinds, and for various purposes, by varying the materials of the compositions. Cementation is generally a very powerful method of producing changes upon bodies, or of forming combinations which could not otherwise be easily effected; because in this operation the active matters of the cement are in a state of dryness, are reduced into vapors, and assisted by considerable heat.

#### CLIV. CEMENT - COPPER. (b)

#### CLV. CENTAURY. (c)

CLVI. CERUSS, or WHITE LEAD. Ceruss is a kind of rust of lead which has been corroded and half-dissolved by vapors of vinegar. To make ceruss, leaden plates rolled spirally, so that the space of an inch shall be left betwixt each circumvolution, must be placed vertically in earthen pots of a proper size, containing some good vinegar. These leaden rolls ought to be so supported in the pots, that they do not touch the vinegar, but that the vapor of this acid may circulate freely betwixt the circumvolution; these pots are to be covered, and placed in a bed of dung, or in a sand-bath, by which a gentle heat may be applied. The acid of vinegar, which very well dissolves lead, being thus reduced into vapors, easily attaches itself to the surface of these plates, penetrates them, and is impregnated with this metal, which it reduces to a beautiful white powder called *Ceruss*: when a sufficient quantity of it is collected on the surface of the plates, the rolls are taken out of the pots, and unfolded; the ceruss is then taken off, and they are again rolled up, that the operation may be repeated.

This management is very ingenious; because the plates of lead thus disposed present the greatest surface to the vapors of vinegar, while they occupy the least possible space.

As in this operation the acid of vinegar is overcharged with lead, this metal thus changed into ceruss, is not properly in a saline state; hence ceruss is not in crystals, nor is soluble in water: but a saline quality would render it unfit for painting, for which it is chiefly employed.

Ceruss ground and prepared for painting is called *white lead*. It is the only white hitherto found fit for painting in oil. The discovery of another white for this purpose is desirable, not only from its faults as a paint, but also from its injuring the health of persons employed in its manufacture, by affecting them with a severe disease, which lead and all its preparations frequently occasion, called the *colic of miners*, or the *colic of painters*.

Ceruss, like the other preparations of lead, is drying, sedative, and lenient; as such it is employed, but only externally. It is an ingredient in many oint-

(b) *Oxment*, or *Ziment Corras*, is copper precipitated from vitriolic waters by iron. The name is derived, as is said, from a vitriolic water in Hungary called *oxment*.

(c) *Centaurium*, the name of the plant.

fer centaury contain a bitter substance soluble by water, or by spirit of wine. The green color of the plant resides in the resinous part, being extracted by spirit of wine, but not by water.

ments, plaisters, and other pharmaceutical preparations designed for external maladies.

As lead is much divided in cerufs, and is already penetrated with a certain quantity of acid of vinegar, its saturation with this acid may be easily completed, by dissolving cerufs in distilled vinegar. Thus the lead is entirely reduced to a saline state. From this saturation a crystallizable neutral salt with metallic basis results, called *sugar* or *salt of lead*. See SUGAR of LEAD.

CLVII. CERUSS of ANTIMONY. This name is given by some chemists to a pearl-colored matter, or white earth, which separates from the water with which diaphoretic antimony has been washed. It is the finest part of the white calx of antimony, which has been dissolved by the alkali of nitre formed in this operation. The peculiar earth of the alkali, some of which always separates after every calcination and solution, probably makes a part also of the cerufs of antimony. See DIAPHORETIC MINERAL.

CLVIII. CHALK. Chalk is a calcareous earth, found in form of friable stones, and therefore cannot be polished as marble and other hard calcareous stones may. Chalk is also found in powder. This substance has all the properties which characterize calcareous earths. See EARTHS (CALCAREOUS).

CLIX. CHALK (BLACK). (*d*).

CLX. CHARACTERS. Chemical characters are signs invented to represent the principal substances and operations in a concise manner. These signs ought to be understood, because they are used by many authors, and in tables of affinities. See the PLATES.

CLXI. CHEESE. Cheese is the mucilaginous or gelatinous part of milk. As the milk of all animals is a true emulsion, the cheese or caseous part of milk is an intermediate substance by which the oily or butyraceous part of this liquor is divided, and suspended in the serous part. Thus cheese is in milk what mucilage is in emulsions or milky juices of vegetables; but although it has some properties common with mucilages, it differs in other respects, particularly in its want of ductility, or its visciditv, and in its property of coagulating by heat and by acids.

Milk is composed of three very different substances, butter, cheese, and whey. These substances are only well mixed together, but not combined, since they are capable of a spontaneous separation or analysis: but this separation is not entire and exact, except it be procured by methods peculiar to each of these substances. See BUTTER, MILK, and WHEY.

To have cheese as pure as is possible, fresh milk, after the cream is well taken off, must be curdled by runnet, or by cream of tartar; the whey then must be well drained from it, and it must be frequently washed with much pure water.

If it be then exposed to distillation with a graduated heat, at first a phlegm arises which has a slight smell of milk or of cheese, without any marks of an acid or of an alkaline quality. This phlegm arises with the heat of boiling water;

(*d*) CHALK (BLACK); *humus nigra pictoria*; *atramentum scissile*. This is a light, earthy, flakey substance used for drawing black lines on paper, and for mixing with oil or water for the use of painters. It is cal-

cineable by fire to a reddish white earth. It is unsoluble by acids, and seems to be a bituminous slate. It is found in Sweden, near Funenberg; a black earth is found as diffusible in water as Indian ink.

and.

and when the heat is increased an oily, and saline spirit arises. The saline part of this spirit is generally a volatile alkali. Afterwards a small quantity of empyreumatic oil arises, which is at first fluid, and becomes more and more thick and fetid. Concrete volatile alkali also arises in this distillation; and at length when the retort is very red-hot, and nothing more rises, a considerable quantity of coal remains. This coal is of that kind which cannot be burnt without very great difficulty.

From this analysis of cheese, which resembles the analysis of all animal matters, this substance appears to be the most animalised part of the milk; for butter and whey furnish other principles, and particularly much acid. We must, however, observe, that cheese made of the milk of frugivorous animals may furnish more, instead of volatile alkali. This difference depends perhaps on the nature of the elements used by the animals from which the milk is taken, and also of the temperaments, dispositions, and nature of their digestions; for, in general, the state of the acid, and its greater or less disposition to be transformed into volatile alkali, are very variable in the animal kingdom, particularly in those animals which live only on vegetables, and in their milk, which still more approaches a vegetable nature.

This matter, although very interesting, has been much neglected by chemists. We find, in the *Elements of Practical Chemistry*, an analysis of cheese produced from cows milk, and in that analysis no mention is made but of an acid, which shews the variations that may happen in this matter. We wish it were examined as accurately as it deserves; but for this purpose many experiments which require much time and favorable circumstances ought to be made; which could not be done without having several cows of different ages, fed with different herbs and grains, at different periods from their having calved, and at different seasons of the year. See MILK.

**CLXII. CHEMISTRY.** Chemistry is a science, the object of which is to discover the properties of bodies by analysis and by combination.

The advantages resulting from this science are too manifest and too numerous to require an enumeration in such a work as this.

**CLXIII. CHERT.** (e)

**CLXIV. CHRYSOLITE.** (f)

**CLXV. CINNABAR.** Cinnabar is of two kinds; one is native, the other is artificial.

(e) **CHERT**, or **CHERTZ**; *petrosilex semipellucidus, lapis communis, bernstein of the Germans.* Chert is a semi-transparent stone of the siliceous kind. See its chemical properties under the article **EARTH (VITRIFIABLE)**. It is generally less hard and of a coarser texture, than common flint. Large quantities of chert are found in beds of limestone, as flints are found in beds of chalk, with this difference, that flints consist of loose nodules, and chert often forms large masses of the rock. They are used as grinding stones for grinding calcined flints, and

other hard substances, but have too smooth and close a texture for the grinding of corn.

(f) **CHRYSOLITE** is a pellucid, yellowish-green stone or gem, the sixth in hardness from diamonds, yet susceptible of impression from a file. By fire it suffers no other change than loss of color. It is probably a species or variety of topaz. Its chemical properties see under the article **EARTH (VITRIFIABLE)**. This gem may be imitated by adding twenty grains of crocus martia to two ounces of crystal-glass, and six ounces of minium.

Native cinnabar is a heavy and brittle mineral, of a very deep red color when it is in a lump, and consists of shining, needle-like, parallel fibres.

This mineral is composed of mercury and sulphur, as will be proved when we shall relate its analysis. It is, properly speaking, mercury mineralised by sulphur, or a true ore of mercury.

Cinnabar cannot be attacked in the humid way by any chemical agent. It is volatile, so that, when exposed to fire in close vessels, it is entirely sublimed, without suffering any decomposition. The sublimation may be repeated any number of times without any change upon the substance.

If cinnabar be exposed to the action of fire, with access of air, it is decomposed by the burning of its sulphur, and then the mercury disengages itself in vapors; but as these vapors are not easily to be collected, and as many of them would be lost by this method of decomposition with access of air, another method is employed of decomposing cinnabar in close vessels, by means of some substance to which sulphur has a greater affinity than to mercury. Many substances are known to be possessed of the quality required for this purpose.

Fixed alkalis, quicklime, calcareous earths, iron, copper, tin, lead, silver, bismuth, and regulus of antimony, have a greater affinity than mercury has to sulphur, and consequently are capable of decomposing cinnabar. Of these substances iron is found to be the most convenient, and is therefore most used for the decomposition of small quantities of cinnabar. When this decomposition is to be made, equal parts of filings of iron and cinnabar are to be well mixed together, and put into a retort, which is to be exposed in a furnace to a naked fire, or in a sand-bath so disposed that a sufficiently strong heat may be applied; a receiver containing water is to be adapted to the retort, and the distillation to be promoted. The mercury disengaged from the sulphur by means of iron is raised into vapors, most of which are condensed in the receiver, at the bottom of which, under the water, they appear changed into fluid mercury; a small part of the mercury remains much divided, and floats on the surface of the water in form of a black powder, which must be carefully collected, and mixed with the mass of fluid mercury, with which it easily incorporates; this mercury, which is then to be strained through closely woven linen, is very pure. It is called *mercury revived from cinnabar*; and this reduction is called *revivification of mercury from cinnabar*. In the retort is found a mass composed of the iron employed, and of the sulphur of the cinnabar; or if, instead of iron, some other substance was employed, it would be found after the operation united with the sulphur. Thus if an alkali or calcareous earth has been employed, an earthy or alkaline liver of sulphur will be found. *See SULPHUR.*

By weighing the cinnabar employed in this process, and the mercury obtained by it, this mercury is found to be seven-eighths of the whole cinnabar. Thus in cinnabar seven parts of mercury are united with one part of sulphur.

From a knowledge of the constituent parts of cinnabar we may learn a method of composing an artificial cinnabar entirely similar to the natural. For this purpose, mercury and sulphur must be fused and triturated together till they unite well, and form a black body called *Ethiops mineral*, or *Regulus of antimony*. This *Ethiops mineral* is then to be sublimed; but we must observe, that the operation is attended with some difficulties; so that a beautiful and perfect cinnabar, in which the mercury and sulphur are exactly proportioned, cannot be obtained.



obtained by the first sublimation. The first sublimate is always overcharged with sulphur, which gives it a black color. The reason of this is, that more sulphur is necessarily employed to make the ethiops mineral than is sufficient to form cinnabar: but by each subsequent sublimation some of that superfluous sulphur is separated, till at length, by five or six sublimations, it becomes entirely similar to native cinnabar. (g)

**CLXVI. CINNABAR of ANTIMONY.** An artificial cinnabar may also be obtained from the decomposition of corrosive sublimate by antimony. This operation is performed by mixing together and distilling these two compound substances. The marine acid of corrosive sublimate, which has a stronger affinity to regulus of antimony than to mercury, quits this latter substance to combine with the former, with which it forms a new compound called *butter of antimony*, that passes by distillation into the receiver. See **BUTTER of ANTIMONY.**

Also the mercury of the corrosive sublimate, being disengaged from its marine acid, unites with the sulphur of the antimony likewise disengaged from its regulus; and these two substances, thus united, are sublimed in form of cinnabar after the butter of antimony has been distilled: but although in this process the mercury is not previously united with the sulphur into an ethiops, the same superfluity of sulphur is perceived in the cinnabar produced by this as by the former operation; because the quantity of antimony necessarily employed for the complete decomposition of corrosive sublimate, contains more than the requisite quantity of sulphur for the formation of perfect cinnabar with the quantity of mercury contained in the corrosive sublimate. This inconvenience is to be remedied by the method directed in the former process, that is, by repeating the sublimation till the cinnabar becomes perfect, and entirely similar to the native. It is called *cinnabar of antimony*, because its sulphur has been furnished by antimony.

The chief use of cinnabar is for painting. Although this body be composed of sulphur, the color of which is a light citron, and of mercury which is white as silver, it is nevertheless of an exceeding strong red color. Lumps of it are of a deep brown red, without brilliancy. But when the too great intensity of its color is diminished by brushing it and dividing it into small parts, (which is a method generally used to lessen the intensity of all colors) the red of the cinnabar becomes more and more exalted, flame-colored, and exceedingly vivid and brilliant. In this state cinnabar is called *vermilion*.

Cinnabar is often employed as an internal medicine. Hoffman greatly recommends it as a sedative and antispasmodic; and Stahl makes it an ingredient in his *temperant powder*. Other very intelligent physicians, and particularly Mr. Carricoter, deny that cinnabar taken internally has any medicinal quality. Their opinion is grounded on the insolubility of cinnabar by any menstruum. This question concerning the nature of cinnabar taken internally cannot be decided without more researches and experiments. But cinnabar is certainly used

(g) Hoffman says, the cinnabar may be produced without the use of antimony by heating or digesting a little mercury with volatile tincture of sulphur, by which means the mercury inhibits the sulphur from the volatile tincture, and forms with it a deep red powder, the color of which is not inferior to that of the ordinary cinnabar.

successfully to procure a mercurial fumigation, when that method of cure is proper in venereal diseases. For this purpose cinnabar is burnt in an open fire on red-hot coals, by which the mercury is disengaged, and forms vapors, which being applied to the body of the diseased person, penetrate through the pores of the skin, and produce effects similar to those of mercury administered by friction.

When fumigations of cinnabar are applied, the patient ought not to be exposed to breathe the vapors of the mercury and of the burning sulphur, which might injure him. See MERCURY and SULPHUR. (b)

CLXVII. CINNAMON. (i)

CLXVIII. CIVET. (k)

CLXIX. CLAY, or ARGILLACEOUS EARTH, is a particular kind of strong earth, considerable banks of which are found almost every where, at greater or less depths. The general properties and characteristics of pure clay are:

1. This earth makes no sensible effervescence with acids, although it be capable of solution by acids, as we shall see.
2. Clay being moistened with water, imbibes some of that liquid, swells, and mixes with it.
3. When it is mixed with no more than the necessary quantity of water to reduce it to a moderately soft paste, it is so ductile as to be capable of being worked upon a potter's wheel, and of being formed in moulds. By these means vessels may be made of it which keep their form.
4. Clay is dense, compact, and close. When its surface is rubbed with a polished body, it also becomes polished.
5. If it be exposed when moist to a gentle heat, it gradually dries and contracts; that is, its dimensions become less, hence it is very apt to crack. (l) It retains moisture pretty strongly, and difficultly allows the last portions of it to escape.
6. If clay be heated much, and quickly, before it be perfectly dried, it bursts with loud noise from the effort made by the water rarefied and changed into vapor, to escape from the parts of this tenacious earth which envelop it. Thus this bursting and cracking do not happen, if the clay exposed to heat contain water enough to render it soft; because then the water finding much less resistance from the clay, only separates the argillaceous parts from each other, and escapes with considerable intumescence.

(b) Some native cinnabars, according to Bruckman, (*Epistol. Itiner.*) are so hard, that they are polished, turned in a lathe, and wrought like marble.

(i) CINNAMON. From 16 oz. of the best cinnamon scarcely more than two scruples and a half of essential oil can be obtained. This oil may be raised by distillation with water, but scarcely with spirit of wine. The whole taste and flavor of cinnamon may be extracted by digestion with spirit of wine. *Newman.*

(k) Civet is an odoriferous unctuous animal juice, soluble in oils, but not in spirit of wine, nor in water, even by means of sugar. *Newman.*

(l) Dr. Lewis found from experiments, that pure clay softened with water to a due consistence is to be worked upon a potter's wheel, continued by drying, and part of every dimension.

7. If pure clay, previously well dried, be exposed to a very violent fire, such for example, as the fire of a glass-house, it does not melt, and resists much more than sand does the action of fluxes and vitrifying matters. By fire its parts are only very strongly agglutinated; and the mass of clay thus calcined is called *baked clay*. During this baking it contracts in every dimension, and becomes as hard as flint, so that it is capable of striking fire with steel.

8. When clay has been thus baked by fire, it becomes no longer penetrable by water. If it be ground and levigated, it mixes with water as very fine sand does; that is, it does not form, as the crude clay does, a tenacious, ductile paste, fit to be turned on a potter's wheel.

9. Clay is entirely soluble in acids, and particularly in the vitriolic, with which acid it forms a vitriolic salt with an earthy basis, which is true alum. See ALUM.

10. Lastly, clay, which, when unmixed, perfectly resists the most violent fire without shewing any tendency to fusion, being mixed with equal parts of any calcareous or gypsous earth, and with two parts and a half, or three parts of any sand or vitrifiable stone, now becomes fusible, and disposes the other two earths to fusion.

All the properties which we have enumerated are essential to argillaceous earth, when perfectly pure; that is, when free from any mixture of heterogeneous matter. Clay so perfectly pure has never yet been found in the earth.

Mr. Macquer, in his *Memoir upon clays* given to the Academy in the year 1762, from which Memoir the greatest part of the present article is taken, observes, that clay being an earth miscible with water, is liable to mixture with many other matters, and that from this cause we never find pure clay, which ought eminently and exclusively to possess the argillaceous properties, and which ought to be always the same, without any peculiar differences; and lastly, that the only certain method of procuring this earth is to extract it from native clays, or from other bodies which contain it, by means of vitriolic acid, with which it forms alum; and then to decompose this alum by phlogiston or alkalis, which disengage the vitriolic acid; therefore, properly speaking, earth of alum well prepared can be considered as the only pure clay. Further, this earth has so strong affinity with phlogiston, that we cannot expect to obtain it perfectly free from this principle. The general properties of clay, described above, are then solely applicable to this kind of earth. See the word ALUM.

Native clays possess more or less of these properties in proportion as they are less or more altered by mixture of heterogeneous matters.

As clays are very useful in chemistry, in arts, and in many purposes of ordinary life, we shall mention some important parts of knowledge concerning them; as, the methods of discovering their purity, the places where they may be found, and the means of purifying them.

The purity of clays is known by the general properties above related. The more any native clay possesses of these properties, the purer it is.

The substances which hurt the purity of native clays are sand, phlogiston, bituminous matters, vitriolic acid, metallic earths, pyritous matters, calcareous earths, and mica.

Inflammable matters alter the color of clay, which when pure ought to be white. Its color is affected also by colored metallic earths, particularly by those of copper and iron, and by all pyritous matters.

Clay, which is colored only by an inflammable matter which is not metallic, loses its color by fire with access of air, and becomes white. Of this kind are most grey and brown clays, of an uniform color, and not veined.

Clays colored by pyritous matters, or by earths of iron or copper, are not rendered white by fire, till they are perfectly deprived of these metallic earths. A certain quantity of these heterogeneous substances in clay render it fusible. Such clays are known by their colors, which are yellow, red, green, or veined, and marbled with several of these colors. They are the most unfit of all clays for the making of utensils intended to sustain intense heat, such as chemical vessels, and the bricks, crucibles, or pots used in glass-houses.

We may observe, that even the purest native clays are never entirely free from a mixture of some parts of metallic, particularly ferruginous earth. Mr. Macquer, who has examined above eight hundred clays, says, in the above quoted Memoir, that in all that number he did not find one, even amongst the whitest, that was entirely pure and free from metallic matter: but when a very small quantity only of ferruginous earth is in clays; when it is not uniformly mixed with them through all their mass, which is known by a beautiful and pure white color, but is dispersed in small yellow spots, as it frequently is; then such clays ought to be considered as being of a very good quality. The only practical method of separating these ferruginous parts, is to break the clay into small lumps, and to cut out the yellow spots. This ought to be done before the clay is mixed with water; because by washing the ferruginous parts are not separable, but are more intimately mixed with the purer part of the clay.

Pyritous matters, mica, and coarse sand mixed with clays render them brittle, and diminish their ductility. Clays are easily cleansed from the greatest part of these heterogeneous substances by washing; that is, by mixing the clay well with much pure water, which is left to rest till only the finest and lightest parts of the clay remain suspended in the water, the grosser parts having subsided to the bottom: the water then is to be decanted off from the gross sediment, and passed through a fine silken searce: the sediment which is deposited from this decanted and sifted water is the finest and purest part of the clay, and ought to be carefully and cleanly collected and dried. This purification of clay by washing is very necessary when good pottery or porcelain is to be made. *See POTTERY and PORCELAIN.*

The pyritous particles found in clays render them very fusible. A bit of pyrites left in clay which is exposed to a baking fire, always forms a cavity in the clay lined with a black leaden color.

The washing with water is an effectual method of separating from clay even the smallest particles of pyrites; because these particles have essentially a specific gravity much greater than that of clay. But sand and mica are not so easily separated from clay. Mr. Macquer has shewn in his Memoir, that the most careful washing is insufficient for an entire separation of sandy particles contained in clays; because every native clay contains a considerable quantity of sandy particles as fine and as light as the clay itself.

Mica

Mica also cannot be separated from clay for the same reason: but these fine particles of sand and mica, which cannot be separated by washing, do not injure works made of the clay, but are rather useful by preventing cracks in drying and baking. See POTTERY.

The particles of calcareous earths which injure the purity of many native clays, are easily discovered by the effervescence which they make with nitrous acid. This kind of earth cannot be separated from clays by washing, from the fineness and lightness of its parts. Clay containing a certain quantity of calcareous earth is by this mixture rendered fusible, from the sandy particles inseparable from the clay: hence all calcareous clays are improper for making utensils intended to sustain intense heat.

Lastly, vitriolic acid, which appears to have been combined and distributed in a singular manner by nature in all clays, may be separated from them by digesting them in an alkaline liquor, and afterwards by edulcorating this clay with a sufficient quantity of water: but this purification of clays is not necessary for most purposes to which these earths may be applied; because this acid is not injurious. Vitriolic acid mixed with clays renders them capable of decomposing nitre and common salt, and of disengaging the acids of those salts.

These extraneous matters being found naturally mixed with clays either singly, or several together, and in all proportions, occasion a great variety of native clays. No earth has so many different kinds; and undoubtedly from this great variety proceeds the multiplicity of names which are annexed to the several kinds of clay.

The earths called *boles*, *bolar earths*, and *sealed earths*, are true clays. Their names have been chiefly applied to those clays which stick strongly to the tongue, and also to certain clays filled with a large quantity of ferruginous earth, by which they are uniformly colored red or yellow. Other names are applied to clays from their particular uses. Such are *fuller's-earth*, *tile-earth*, *brick-earth*, *potter's-clay*, *pipe-clay*, *porcelain-clay*.

The earths called *marles*, as they are capable of dilution in water, have a certain degree of binding quality, effervesce with nitrous acid, are fusible with an intense heat, and appear to be nothing else than clays more or less sandy, and mixed with much calcareous earth.

Lastly, epithets are given to many clays denoting their color, as *white clays*, *grey clays*, *blue clays*, &c.

But these names communicate little knowledge on the true nature of the several native clays. A more particular examination by chemical proofs is requisite to investigate the heterogeneous matters with which different native clays are mixed, the mixture of which alters the purity of simple and primary argillaceous earth, to which they owe all they possess of argillaceous properties; then names might be given which should indicate their color and the heterogeneous matters with which they are mixed, or at least those which prevail most. Thus amongst these names we should have *white, sandy, micaceous, or calcareous clays*; *grey or blue pyritous clays*; *red or yellow ferruginous clays*; *black bituminous clays*, &c.

As our intention in this work is not to enter into the details of natural history, we shall say no more upon this subject. What we have said concerning the properties of pure clay, and the different substances which alter its purity, and more or less disguise the argillaceous properties of native clays, is sufficient to give a  
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notion

notion of the light which chemistry can throw on natural history in this and many other instances.

In Mr. Gellert's table the substances capable of acting upon clays are set down in the following order: Vitriolic acid, partly (*see* an explanation of this word partly at the article ALUM), liver of sulphur, fixed alkali, borax, calx of lead, calx of antimony, gypseous earth, calcareous earth.

#### CLXX. CLOVES. (*m*)

CLXXI. CLYSSUS. By the word *clyssus* are meant the vapors which rise during the detonation of nitre with any inflammable body. These vapors may be collected and condensed into a liquor by a proper apparatus of vessels.

The vapors resulting from the detonation of nitre with charcoal are called *clyssus of nitre*. To prepare this clyssus, an earthen retort must be employed capable of sustaining a great heat applied suddenly without injury.

This retort, which ought to be tubulated, is to be placed in a furnace, and to it a very large balloon with a small hole is to be adjusted. When the bottom of the retort has become red-hot, a small quantity, that is, a dram and a half, or two drams, of a mixture of purified nitre and charcoal powder, is to be thrown into the retort through the tubulated part, which must be immediately afterwards closed; the nitre then detonates, and the vapors are condensed in the receiver.

Other parcels of the detonating mixture are to be thrown in successively with the same management, till a sufficient quantity of liquor is collected in the receiver. If, instead of charcoal-powder, sulphur be employed to detonate with nitre in close vessels, the liquor obtained is called *clyssus of sulphur*; and if antimony be employed to detonate with nitre, the liquor is called *clyssus of antimony*.

The old chemists who have practised these operations believed, that the liquors thus obtained had particular virtues for alchemical purposes. For this reason, they made this preparation with great apparatus and trouble. But now, when chemical operations are better understood, these liquors are believed to have no virtues. The clyssus of nitre is made in laboratories, not for any use to which it can be applied, but to establish a theory concerning the nature of nitrous acid, and to prove that this acid is entirely destroyed and decomposed by detonation.

For, when the operation is finished, nothing is found in the retort but the alkali which was the basis of the nitre; and the liquor contained in the receiver has no acid taste, does not redden the tincture of turnsol, makes no effervescence with alkaline matters, and is truly nothing but water, which is sometimes slightly

(*n*). CLOVES. The pungency of cloves resides in their resin, or rather in a combination of resin with essential oil; for the spirituous extract is very pungent; but if the oil and the resin contained in this extract be separated from each other by distillation, the oil will be very mild; and any pungency which it does retain proceeds from some small portion of adhering resin, and the re-

maining resin will be insipid. No plant, or part of any plant, contains so large a proportion of essential oil as cloves do. From sixteen ounces Neuman obtained by distillation two ounces and two drams, and Hoffman obtained from the same quantity an ounce and a half. This oil is specifically heavier than water. Neuman.

alkaline,

alkaline, because the force of detonation is capable of raising some small part of the alkali of the nitre.

The clyffus of sulphur is acid, because the vitriolic acid of the sulphur is not decomposed, as the nitrous is, by combustion, but is disengaged and set at liberty by the burning of the phlogiston of the sulphur. Besides, one part of this vitriolic acid when disengaged acts upon the nitre, forms with its basis a vitriolated tartar called *Glafer's sal polychrestum*, and disengages the nitrous acid. This portion of nitrous acid thus disengaged by the acid of sulphur, and which is no longer retained and fixed by an alkali, is not capable of inflaming with phlogiston: wherefore it is not decomposed, and, together with the vitriolic acid which is not fixed by the alkali of the nitre, makes part of the clyffus.

The clyffus of sulphur appears then to be composed, 1. Of a part of the nitrous acid destroyed by inflammation with the phlogiston of the sulphur: 2. Of another portion of nitrous acid which is not decomposed, but is disengaged by the acid of sulphur: 3. Of all the acid of sulphur, which does not unite with the alkaline basis of the nitre.

The clyffus of sulphur must differ considerably according to the proportions of nitre and of sulphur employed. If a little nitre be added to much sulphur, the clyffus will be almost all pure acid of sulphur.

An English chemist \*, some time ago, found a method of obtaining very advantageously the vitriolic acid of sulphur, by burning sulphur in close vessels with a small quantity of nitre. This method of decomposing sulphur for the extraction of its acid is said to be executed in great, and to be the cause of the great reduction of the price of that acid within these few years past. This is an instance of practical utility from a clyffus; for the vitriolic acid obtained by detonation of nitre in close vessels is a true clyffus of sulphur.

The clyffus of antimony is similar to that of sulphur; for the nitre in this operation chiefly detonates with the sulphur of the antimony: however, the phlogiston of the metalline part of the antimony contributes also to the detonation. Besides, some flowers of antimony are mixed with this clyffus.

Several necessary precautions ought to be taken to make this operation of a clyffus succeed, and to avoid accidents; for the rapidity and violence with which nitre detonates in certain circumstances may occasion a strong explosion and rupture of the vessels. To prevent these accidents, the inflammable matters ought not to be very well mixed with the nitre, because the detonation is proportionably stronger and quicker as the mixture has been made more exactly. Also, a small quantity only of the mixture ought to be detonated at once, and another quantity should not be added till the detonation of the former be finished. See NITRE, DETONATION of NITRE, and GUN-POWDER.

**CLXXII. COAGULATION.** This term is employed by chemists to denote certain operations in which fluid bodies become solid; for instance, the crystallization of salts. See CRYSTALLIZATION.

**CLXXIII. COAGULUM.** This Latin word is used to signify curdled concretions formed by the mixture of two liquors, such as the precipitate of silver in the formation of *luna cornea*, the *ossa Helmontii*, the *miraculum chemicum*, and many others. See these words.

\* Dr. Ward. See SPIRIT of SULPHUR.

**CLXXIV. COAL.** By the word *coal* is meant any substance containing oil which has been exposed to fire in close vessels, so that all its volatile principles are expelled, and that it can sustain a red heat without further decomposition. Coal is a body solid, black, very dry, and considerably hard.

The specific character of perfect coal is its capacity of burning with access of air, while it becomes red-hot and sparkles, sometimes with a sensible flame which gives little light, no smoke or foot capable of blackening white bodies.

Coal is capable of communicating its inflammable principle either to the vitriolic acid, with which it forms sulphur; or to the nitrous acid contained in nitre, with which it inflames; or to metallic earths, which it reduces into metals. But the phlogiston cannot pass from coal to form these new combinations without the assistance of red-heat.

Coal seems to be an unalterable compound in every instance but these mentioned, of burning in open air, and of communicating its phlogiston to other bodies: for it may be exposed in close vessels to the most violent and continued fire without suffering the least alteration. No disposition to fuse, nor any diminution of weight can be perceived. It is a substance exceedingly fixed, and perhaps the most refractory which is known.

No change is produced upon coal by air or by water, nor by the most powerful menstruums of chemistry, excepting perhaps by particular processes. A trial might be made whether the concentrated mineral acids, or caustic alkalis, would not, when assisted by heat, make some alteration upon coal in a long time. The younger Mr. Rouelle proposed as a problem, in the *Journal de Medicine* for October, 1762, to *dissolve vegetable coal in the palm of the hand*. Why he proposed it as a problem we do not know; since he adds, that Mr. Wolf has resolved it, and that this solution may be made by liver of sulphur. He has not explained whether he means the solution of all the substance of the coal, or of its phlogiston only.

Coal is evidently a result of the decomposition of the compound bodies from which it is obtained. It consists of the greatest part of the earthy principle of these compound bodies, with which a part of the saline principles, and some of the phlogiston of the decomposed oil are fixed and combined very intimately.

Coal can never be formed but by the phlogiston of a body which has been in an oily state: hence it cannot be formed by sulphur, phosphorus, metals, nor by any other substance the phlogiston of which is not in an oily state.

Also every oily matter treated with fire in close vessels furnishes true coal; so that whenever a charry residuum is left, we may be certain that the substance employed in the operation contained oil. See OIL.

Lastly, the inflammable principle of coal, although it proceeds from an oil, is certainly not an oil, but is pure phlogiston; since coal added to vitriolic acid can form sulphur, to phosphoric acid can form phosphorus, to metallic earths can form metals, and can detonate with nitre; and since oil can produce none of these effects, till it has been decomposed and reduced to the state of coal. See SULPHUR, PHOSPHORUS, METALS, NITRE, and OIL.

Besides, the phenomena accompanying the burning of coal are different from those which happen when oily substances are burnt. The flame of charcoal is not so bright as that of oil, and produces no smoke or foot.



All the phlogiston of coal is not burnt in open air, particularly when the combustion is slow. One part of it exhales without decomposition, and forms a vapor, or an invisible and insensible gas. This vapor, or this phlogiston, disengaged from coal, is very pernicious. It so affects the brain and nerves as to occasion instant death. For this reason, to remain in a close place where charcoal or other coal is burnt, is dangerous. Persons struck by vapor of charcoal are stunned, faint, suffer a violent head-ach, and fall down senseless and motionless. If they are yet alive, the best method of recovering them is to expose them as quickly as is possible to open air, and to make them swallow vinegar, and breathe its steam. Acids, and particularly vinegar, seem to have a property of fixing and restraining in some sort the action of phlogiston, and of the vapors of volatile inflammable matters, which produce similar effects on animals. For this reason, vinegar diminishes the accidents of intoxication occasioned by spirituous liquors and by opium. The vapor which exhales from liver of sulphur, particularly when a large quantity of it is decomposed by an acid; and the vapors which exhale from matters undergoing the spirituous or putrid fermentation, produce the same accidents as the vapors of coal, and are remedied by the same means.

Amongst coals, some differences are observable, which proceed from the difference of the bodies from which they are made; particularly, some coals are more combustible than others. This combustibility of coals seems to depend on the greater or less quantity of saline principle contained in coal; that is to say, that the more it contains of saline principle, the more easily it decomposes and burns. For example, coals made of plants and wood, containing much saline matter capable of fixing it, the ashes of which contain much alkaline salt, burn vigorously and produce much heat; whereas the coals of animal matters, the saline principles of which are volatile, and cannot be fixed but in small quantity, and the ashes of which contain little or no alkaline salt, are scarcely at all combustible. For they not only do not kindle so easily as charcoal does, nor ever burn alone, but they cannot be reduced to ashes without very great trouble, even when the most effectual methods are used to facilitate the combustion.

I have kept the coal of bullock's blood very red-hot in a shallow crucible, surrounded with burning charcoal, six hours and more, and stirred it constantly that it might all be exposed to the air, but I could not reduce it to white or even grey ashes. It remained still very black, and full of phlogiston.

The coals of pure oils, or of concrete oily substances, and soot, which is a kind of coal raised during the inflammation of oils, are as difficultly burnt as animal coals. These coals contain very little saline matter, and their ashes furnish no alkali.

These coals, which are so difficultly burnt, are also less capable of inflaming with nitre than others more combustible; and some of them even in a great measure resist the action of nitre.

The refractory quality of coals is a singular property. This property is in so great a degree, that they are found to be the fittest substances for supporting bodies exposed to the focus of large burning-glasses. Nevertheless all coal is composed of an earth which is not perfectly refractory, of a saline matter which is fusible and assists the fusion of other substances, and of phlogiston which is  
certainly

certainly the principle of the fusibility of metals, as their earths become so much more difficult to fuse as they are more dephlogisticated. (n)

CLXXV. COAL (FOSSIL). (o)

CLXXVI. COATING. (p)

CLXXVII. COBALT. This name is given by authors to several different minerals. We shall here only talk of that kind of cobalt which contains the metallic matter whose calx furnishes a blue glass when vitrified; because the name *cobalt* ought to be confined to this mineral alone, to avoid the uncertainty and confusion too frequent in names of natural history and of chemistry.

Cobalt is a very heavy mineral, of no determinate figure; of a grey color, more or less brilliant; of a fine, compact, close grain, the surface of which,

(n) To make charcoal, or vegetable coal, pieces of wood are so disposed as to form a pile, generally conical, which pile is covered with turf to prevent the too free draught of air, by which the wood would be reduced to ashes and not to coal. The pile is then to be kindled, and the fire is to be continued till all the watery and the more volatile parts of the wood are dissipated; that is, till no more smoke arises, at which time the wood is thoroughly red-hot. The external air is then to be totally excluded, by covering the pile with earth, and thus the fire is extinguished.

(o) COAL (FOSSIL), or PIT-COAL, is a black or brown, laminated, bituminous substance, not very easily inflammable, but which once inflamed, burns longer and more intensely than any other substance. Of this substance three kinds are distinguished by authors. The residuum of the first after combustion is black; the residuum of the second is spongy, and like pounce stone; and the residuum of the third is whitish ashes. Some fossil coal, by long exposure to air, falls into a greyish powder, from which alum may be extracted. Fossil coal by distillation yields, 1. a phlegm and water; 2. a very acid liquor; 3. a thin oil like naphtha; 4. a thicker oil, resembling petroleum, which falls to the bottom of the former, and which rises with a violent fire; 5. an acid concrete salt; 6. an unflammable earth remains in the retort. These constituent parts of fossil coal are very similar to those of amber and other bitumens. See BITUMEN. For the exciting of intense heats, as of furnaces for smelting iron-ore, and for operations where the

acid and oily vapors would be detrimental, as the drying of malt, fossil coals are previously charred, or reduced to coaks; that is, they are made to undergo an operation similar to that by which charcoal is made. By this operation coals are deprived of their phlegm, their acid liquor, and of greatest part of their fluid oil. Coaks therefore consist of the two most fixed constituent parts, the heavy oil and the earth, together with the acid concrete salt, which though volatile is detained by the oil and earth.

(p) COATING, or LORICATION, is an application of clay, or mixture of clay with sand or other substance, to the external or internal surfaces of chemical vessels, to guard them against the effects of sudden heat, or of the corrosive quality of the matter to be contained. Thus glass retorts intended to be exposed to what is called a naked fire, that is, to a fire without interposition of a sand-bath or other substance, ought to be externally coated, by which means they will not be so liable to be cracked by the sudden application of heat and cold. Retorts may be coated in the following manner: Take of clay and sand equal parts; make them into a thin paste, with fresh blood prevented from coagulating by agitation till it be cold, and diluted with water; add to this paste some hair and powdered glass; with a brush dipt in this mass besmear the retort; and when this first layer is dry, let the same operation be repeated twice or oftener, till the coat applied be about one-third part of an inch thick. For the compositions for coating crucibles, furnaces, and other instruments made of plate-iron, see CRUCIBLE.

when

when it has been exposed to the air, is covered with a powder, or efflorescence of the color of a peach-blossom.

This mineral is not found in many places. Hitherto it seems to have been found only in Saxony and in the Pyrenean mountains (*q*). It contains several substances mixed and confounded together, and in this respect some cobalts differ from others. All of them contain sulphur, much arsenic, and the semi-metal the calx of which may be made into blue glass, and which Mr. Brandt of the Swedish Academy calls *Regulus of Cobalt* when it is reduced to its metalline state. Besides these substances, some cobalts contain bismuth, silver, or both of these.

Of all these matters, the peculiar regulus of cobalt renders this mine valuable from the fine blue which is manufactured from it, and which is only blue that can be used in vitrification.

Nevertheless other substances are collected from cobalt in the operation practised on it, but only secondarily, because these substances may be obtained without additional labor or expence. For example, as it is necessary in the preparation of the blue to expel the arsenic, this mineral must be exposed to long roastings; instead of dissipating the arsenic which rises in vapors during the torrefaction, it is collected in long crooked chimneys, adapted to the furnaces in which the cobalt is roasted, and thus is obtained almost all the arsenic which is sold in commerce. See ARSENIC.

Likewise after the roasting, when the calx of cobalt is fused with vitrifiable matters to make the blue glass called *Smalt*, the bismuth and silver may be separated and collected.

(*q*) Cobalt has been found in Cornwall, Scotland, and probably in other parts of Europe. That it is in the eastern parts of Asia, appears from the blue coloring on old oriental porcelain. Probably also the mines discovered in these countries are nearly exhausted, as considerable quantities of zaffre and smalt are exported from Europe to China. Besides the grey or ash-colored cobalt described in the text, which is the most frequent, other cobalts are found of various colors and textures, mixed with various substances. Wallerius enumerates six species of cobalts. 1. The *ash-colored ore*, which is regulus of cobalt mineralised by arsenic, consisting of shining leaden-colored grains. Some ores of this kind are compact, resembling steel, and others are of a loose texture and friable. 2. The *specular ore* is black, shining like a mirror and laminated. This species is very rare, and is supposed by Wallerius to be a foliated spar, or selenites mixed with ore of cobalt. 3. The *vitreous, or slag-like ore*, is of a blueish, shining color, compact, or spongy. 4. *Crystallized ore of*

*cobalt* is a grey, deep-colored ore of cobalt, consisting of clusters of cubical, pyramidal, prismatic crystals. 5. *Flowers of cobalt*, red, yellow, or violet. These flowers seem to be formed from some of the above described compact ores, decomposed by exposure to moist air. This decomposition is similar to that which happens to ferruginous and cupreous pyrites. 6. The *entire ore of cobalt* is of a greenish white or of a yellow color, and of a soft and friable texture. This species seems to be an ochre of cobalt, and is formed perhaps from the flowers of cobalt further decomposed, in the same manner as a martial ochre is formed from the saline efflorescence of decomposing pyrites, when this efflorescence is further decomposed by exposure to moist air; by which the vitriolic acid contained in it is expelled, and the efflorescence is changed from a saline state to that of an ochre or calx. Besides these proper ores of cobalt, it is also found in a blue clay along with native silver, in ores of bismuth, and in the mineral called kupfer-nickel. See NICKEL.

The blue, although a valuable metal, is generally in so small a quantity, that it would not be worth the trouble of obtaining on purpose from this mineral. The cobalt is therefore always operated upon for the sake of the blue.

If well-calcined cobalt be treated with phlogiston and fluxes, like other metallic calxes, it will be reduced to a semi-metal, called by Mr. Brandt, who first discovered it, the *Regulus of Cobalt*.

This regulus, and also the calx of cobalt, amongst other singular properties, has that of making a very curious sympathetic ink, by being dissolved in aqua regia. See, for what further relates to cobalt, the articles *SMALT*, *ZAFFRE*, *AZUR*, *REGULUS of COBALT*, and *INK (SYMPATHETIC)*.

CLXXXVIII. COCHINEAL. (r)

CLXXXIX. COERULEUM MONTANUM. (s)

CLXXX. COHESION. By cohesion is meant the adhesion which the integrant or the constituent parts of bodies have to each other.

CLXXXI. COHOBATION. Cohobation is an operation by which the same liquor is frequently distilled from the same body, either with an intention to dissolve this body, or to produce some change upon it. This is one of those operations which the ancient chemists practised with great patience and zeal, and which are now neglected.

To make this operation easier, and to prevent the trouble of frequently changing or moving the vessels employed, a particular kind of alembic is contrived, very convenient and well adapted, called a *Pelican*. See *PELICAN*.

CLXXXII. COLCOTHAR. Colcothar is the substance which remains from the calcination and distillation of martial vitriol with a violent fire.

Vitriolic acid does not adhere so strongly to the iron of the martial vitriol as to be capable of resisting the action of a strong fire; therefore when this vitriol is heated intensely and during a long time, it loses more and more of its acid, which is dissipated if the calcination be performed in open vessels, and which may be distilled with proper apparatus. When the vitriol loses its

(r) COCHINEAL. From an ounce of cochineal Neuman obtained by distillation two scruples of phlegm, four scruples of urinous spirit, fifteen drops of oily spirit, twenty-two grains of volatile alkali, five scruples and two grains of empyreumatic oil, and two drams and two scruples of a residuum containing five grains of fixt lixivial salt. The same author found that of four drams of cochineal, three drams were soluble in water, and nearly as much in spirit of wine.

Cochineal infused or boiled with water produces a crimson tincture inclining to purple. Fixed alkali renders the crimson deeper, but lessens its lustre. Volatile alkali heightens the color without diminution of lustre. The best method of applying volatile alkali for this purpose in dyeing was found by Mr. Helot to be, by dipping the cloth dyed with

cochineal in a solution of sal-ammoniac, and then throwing into the solution some potash, by which the volatile alkali of the sal-ammoniac is disengaged. By a small quantity of vitriolic acid the crimson decoction of cochineal is rendered purple, by more of that acid it is rendered flesh-colored, and by still more colorless. This color is first changed to a yellow, and afterwards destroyed by nitrous acid. Solution of tin in aqua regia heightens the color of this decoction to a scarlet. French dyers give a scarlet tinge to this decoction by turmeric; but this tinge does not penetrate the cloth, and is not durable. See *DYING*.

(s) COERULEUM MONTANUM, *mountain-blue*, called by some authors *chrysocolla*, is a blue ore of copper. See *ORES of COPPER*.

acid,

acid, it acquires a red color, and becomes an earthy matter. The calx of iron, whether it has been deprived of phlogiston by fire or by acids, is always of this red color: but the iron contained in vitriol suffers this alteration during the calcination. When the calcination is finished, what remains of the vitriol has still some taste, and even the property of becoming moist when exposed to air. These qualities are caused by some remaining acid which adheres obstinately to the earth of the iron, and which the fire could not expel. As this acid is very much concentrated, and is not combined with the calx of iron in the colcothar, as it was with the iron itself in the vitriol, because the phlogiston of the iron is lost by calcination, we need not wonder that this calcined vitriol should powerfully imbibe moisture from the air, although vitriolic does not.

This remaining acid may be taken from the colcothar by washing with water. The colcothar then has no taste, does not attract moisture from the air, and is called *Sweet Earth of Vitriol*.

Unwashed colcothar is used in medicine, but only externally. It may be properly applied to all putrid, sanious and fungous ulcers, because it is antiseptic, strongly tonic, astringent, and even corrosive, from its remaining uncombined vitriolic acid. See VITRIOL (MARTIAL) and CALCINATION.

CLXXXIII. COLOPHONY. Colophony, or rosin, is the resinous residuum after the distillation of the light oil from turpentine. It has also the properties of other resins, and the same principles may be obtained from it by analysis. See BALSAMS (NATIVE); TURPENTINE; and RESIN.

CLXXXIV. COLOCYNTH. (t)

CLXXXV. COLORS. (u)

CLXXXVI. COMBINATION. By the word *combination*, we ought to understand the union of two bodies of different natures, from which a new compound body results. For example, when an acid is united with an alkali, we say that a combination betwixt these two saline substances takes place, because from this union a neutral salt results which is composed of an acid and an alkali. See COMPOSITION.

CLXXXVII. COMBUSTION. Combustion is nothing else than the disengagement of the inflammable principle contained in several kinds of bodies, which are therefore called *combustible*.

The principle of inflammability is united in greater or less quantity with bodies, and in several different manners; hence the diversity occasioned in the phenomena of combustion.

If the phlogiston of a body be in large quantity, and in an oily state, this body is very combustible, and burns with a bright flame, accompanied with smoke and soot. Wood, dry vegetables, resins, oils, fat, are combustible bodies of this kind.

If the phlogiston of a body be not in an oily state, but in large quantity, or not very intimately combined, this body may also be very combustible, and may

(t) COLOCYNTH, or COLOQUINTIDA, is a bitter fruit, from an ounce of which Neuman extracted by spirit three ounces and a half, and by water seven ounces and a half. (u) Colors. See BLACK, BLUE, &c. and DYING.

even burn with flame. But this flame is slighter and generally less luminous than the flame of oily bodies; besides, it is accompanied with no smoke or soot. Spirit of wine, sulphur, phosphorus, charcoal, some metallic matters, and particularly zinc, are combustible bodies of this kind. The flames of phosphorus and of zinc are nevertheless very luminous.

Lastly, bodies containing phlogiston which is not in an oily state, and which is in small quantity, or strongly combined with other uncombustible principles, burn difficultly without any sensible flame; such are certain animal coals, soot, ashes of vegetables containing very little phlogiston, and imperfect metals.

The grand principle concerning combustion in general is, that no combustible matter can burn without access of air, and that the more immediate its contact with air is, the more rapid and compleat is its combustion. See AIR.

For this reason, even the most inflammable bodies, as spirit of wine and ethereal oils, do not burn but at their surface, because that only is exposed to air. For the same reason, inflammable bodies, when reduced to vapor, burn rapidly and instantaneously, because they are all exposed to air at once. Lastly, for the same reason, some bodies, though full of phlogiston, such as fat, oils, &c. cannot burn without a heat sufficient to reduce them into vapor.

The practical methods of promoting, accelerating, and of compleating the combustion of the inflammable principle of bodies may also be naturally deduced from what we have said on this subject. These methods consist in applying as much of these bodies as possible to the air. Thus by directing a current of air upon the burning bodies, their combustion is accelerated and augmented in proportion as this current is stronger, as the effects of bellows and air-furnaces evidently prove.

Most oily bodies, as wood, burn with much flame, which lasts while any sensible quantity of oil remains: after which the flame ceases. They are not however yet deprived of all their inflammable principle, a part of which remains in the state of coal. Then the remaining part of the body may continue to burn, if it contains much phlogiston, but without a luminous flame, and in the manner of charcoal.

In proportion as the phlogiston is consumed by this second combustion, what remains of it becomes more and more difficultly combustible; not only because the least fixed and adherent part of it is first burnt, but also because the proportion of incombustible matter, to which this phlogiston is united, becomes greater and greater. Hence when this combustion has arrived at a certain point, that is, when a small portion of phlogiston only remains strongly combined, and also covered and defended by a large quantity of incombustible matter, this remaining phlogiston will not burn alone, and is nearly in the same state as that of most metallic matters. If, therefore, this combustion is to be compleated, which then is called *calcination*, fire must be applied from some other fuel, with which the body to be calcined or dephlogisticated is to be penetrated, and kept red-hot; and as much air is at the same time to be applied to the body, till no longer any marks appear of its inflammable principle. Ashes of vegetables, soot, coals of oils and of animal matters, and several metallic substances, contain some phlogiston in this last state.

When the phlogiston of these substances is to be entirely burnt or dissipated, all the means capable of favoring combustion ought to be made to concur.

The

The substances ought to be first divided into very small parts, because then they present more surface to the air than when in one mass. They are then to be exposed to the action of fire in a convenient vessel, so that the air may have free access; as for example, in a wide-mouthed test, and under a muffle open on the side at which air is introduced into the furnace. To accelerate further this operation, a current of air may be directed upon the surface of these bodies, and they may be frequently stirred, that all their parts may be successively presented to air. The strongest fire which the matter can sustain without fusion ought to be applied; because a melted body forms always one mass, and presents less surface than when it is divided in small detached parts. Thus fusible bodies, as ashes, alkaline salts and metals, ought to be calcined with a moderate heat, and proportioned to their fusibility.

The last portions of the phlogiston of certain bodies are so difficultly combustible, that notwithstanding all these means united, they never can be entirely burnt.

Some of them even, as the perfect metals, are considered as bodies entirely incombustible, because they can sustain the most violent fire during entire months, without suffering any sensible alteration. Nevertheless, Junker affirms, that gold and silver may be calcined, if they are treated during six months, by reverberation, in the manner of Isaacus Hollandus.

Although the certainty of this experiment has not been sufficiently confirmed by repeated trials, the method of calcining these metals proposed by this chemist agrees so well with the great principles of combustion, that its success seems very probable. See CALCINATION.

CLXXXVIII. COMPOSITION of BODIES. Chemical composition is the union and combination of several substances of different natures, from which a compound body results. From this union of bodies of different nature a body is formed of a mixed nature, which Becker and Stahl have called a *mixture*, and which may be called a *combination* or *chemical composition*, to avoid the equivocal sense of the word *mixture*, by which may be understood only a mere interposition of parts, and which therefore would give a very false idea of chemical composition, in which a mutual adhesion takes place between the combined substances.

When the substances considered by chemists as *simple*, or *primary principles*, are combined together, they form the first compounds, to which Becker and Stahl give, by way of excellence, the name *Mixts*. The same chemists call the bodies formed from the union of these mixts, *compounds*. When they treat of more complicated combinations, they talk of *decompounds* and *furdecompounds*.

This distribution of bodies, more or less compounded, is just and conformable to experience. But the names given by Becker and Stahl are not sufficiently clear and accurate.

A more simple and clear method of distinguishing these several classes of bodies seems to be by numbers indicating their degree of composition. Thus we might say, compounds of the first, of the second, of the third degree, &c. as Mr. Macquer proposes in his course of chemistry.

CLXXXIX. CONCENTRATION. The concentration of a body consists in approximating its proper and integrant parts, by taking away some

some substance interposed betwixt these parts, and which is extraneous, or superabundant to the body to be concentrated. Thus, for instance, a solution of any saline substance in water may be concentrated by expelling part of the water of this solution. But custom has applied the word concentration to the dephlegmation of acids, and particularly of vitriolic acid by distillation, and of vinegar by congelation. We proceed to both these concentrations.

#### CXC. CONCENTRATION of VITRIOLIC ACID.

Vitriolic acid, procured either from vitriol or from sulphur, is never sufficiently pure for chemical operations. It always contains some extraneous substances from which it must be purified.

The heterogeneous matters which chiefly affect the purity of vitriolic acid, are superabundant water by which it is weakened, and inflammable matter by which it is rendered black and sulphureous. These two substances are separable by one and the same distillation, which is called the *concentration*, or the *rectification of vitriolic acid*. This acid ought to be distilled, whether it be both watery and sulphureous, or have only one of these faults.

To explain what passes in this operation, and the management which must be observed, we will first consider what happens in the concentration of vitriolic acid, which is only diluted with superabundant water, and not phlogisticated. We will then proceed to the changes produced upon this acid by distillation, when it is sufficiently free from water, and is only phlogisticated.

When vitriolic acid, diluted with superabundant water, is to be concentrated, if it contains a considerable quantity of water, it may be disengaged from the greatest part of this superfluous water in stone or glass bottles, without the apparatus of distillation. The greater the quantity of water which is united with the vitriolic acid, the less strongly does a part of it adhere. As this water is much more volatile than vitriolic acid, it evaporates by almost the same degree of heat which is requisite to the evaporation of pure water. While the water exhales, the parts of the vitriolic acid remaining in the vessel are approximated, and the acid becomes more and more concentrated and strong. Thus the operation proceeds very well to a certain point, and even better than by distillation. But when the acid has arrived at a certain degree of concentration, it cannot be completed in open vessels; because the smaller which the quantity is of water united to the acid, the more strongly it adheres; so that it cannot be separated without a heat sufficient to raise the acid also, which therefore in open vessels would be lost. But also another and more remarkable inconvenience occurs, which is, that when vitriolic acid begins to be much dephlegmated and very strong, it becomes so greedy of moisture that it attracts that of the surrounding air, as Mr. Beaumé has well observed, and perpetually combines with it; so that every instant it resumes as much water from the air as it loses by evaporation. The concentration of this acid must therefore be completed in close vessels by distillation.

For this distillation, a retort of good glass, capable of resisting acids, must be filled half full with the vitriolic acid to be concentrated, and set in a sand-bath covered entirely with sand. After a receiver has been adapted to it, heat must be applied, and very gradually augmented till drops are distilled.

If the vitriolic acid contains little water, the distillation does not begin but with a considerable degree of heat, and the drops which fall into the receiver are



are very acid. These drops fall very slowly, and the distillation must not be too much hastened. As the concentration advances, the drops follow each other at longer intervals, although the acid contained in the retort acquires more and more heat. Towards the end of the operation, and when the acid is much concentrated, care must be taken not to encrease the heat so much as to make the acid boil, which cannot be effected with less than a red heat. By this heat all the acid may be raised at once, in drops and burning vapors, which pass precipitately, and generally burst the retort.

When this accident happens, whether it proceeds from hastening the distillation too much, or from cold air striking the retort, the concentrated and burning acid is almost entirely reduced to white, thick, suffocating vapors which instantly fill the laboratory. The operators ought to remove themselves from such hurtful vapors.

The duration of this operation, and the quantity of phlegmatic acid to be distilled, so that the vitriolic acid shall be left highly concentrated, are absolutely indeterminate, as they depend on the degree of strength which this acid had before its concentration. The vitriolic acid, which was formerly kept by druggists, required that one half of it should be drawn off by distillation to make the remaining part twice as heavy as water. At present, it is much stronger, although cheaper. Some may be got very concentrated, and which only requires to be dephlogisticated in the following manner.

The vitriolic acid manufactured in the great, and sold in commerce, is always mixed with more or less inflammable matter, by which it is rendered black and opaque. It may be entirely disengaged from this extraneous matter by a distillation similar to that above described.

The first portions of such an acid which passes in distillation are a very penetrating, volatile, sulphureous acid. If the phlogisticated vitriolic acid which is rectified be also phlegmatic, the distillation may be so managed that the liquor shall slightly boil. This liquor continues black till it is concentrated to a certain degree; when by help of a strong heat which it then acquires, the concentrated acid acts upon the inflammable matter, dissipates it, or completely burns it. The liquor in the retort becomes gradually clearer, and at length perfectly white and transparent. If this acid has also the requisite degree of concentration, the operation is finished when it thus becomes perfectly white and transparent. The retort must be left in the sand-bath till it is cold, and then the acid is to be poured into a clean, dry, crystal glass bottle; considering that the smallest piece of inflammable matter is capable of phlogisticating and blackening rectified vitriolic acid; and that any moisture, besides weakening the acid, might occasion such heat as to break the bottle. When the acid is poured into the bottle, the neck of this bottle ought to be wiped dry, and closed by a glass stopper, accurately fitted and well wiped. The mouth of the bottle ought also to be guarded from dust by being covered with leather.

The phlegmatic or sulphureous liquor, which passed over into the receiver, is called *Spirit of Vitriol*. It is clear and white, and may be used in many operations where concentrated vitriolic acid is not requisite, or it may be concentrated and rectified.

**CXCI. CONCENTRATION of VINEGAR by CONGELATION.** Vinegar produced by the acetous fermentation is a vegetable acid

acid much used in chemistry. As this acid is mixed with much extractive matter and superabundant water, chemists have endeavored to render it more pure and strong.

It may easily be disengaged by a single distillation from almost all its extractive matter; see VINEGAR (DISTILLED); but it cannot so easily be deprived of its superabundant water. If vinegar be distilled with intention to concentrate it, as vitriolic acid is, the most watery and least acid part would always rise first; but the operation would succeed very imperfectly, because this acid is almost as volatile as water. To procure the concentration of vinegar, other expedients must be used. Chemists have discovered several which succeed well. For instance, by combining this acid with fixed matters, such as fixed alkalis and metals, and afterwards subjecting to distillation the salts resulting from such combinations, a very concentrated acid of vinegar is obtained, called, *Radical Vinegar*. See upon this subject TERRA FOLIATA TARTARI, SALT of LEAD, CRYSTALS of VERDIGREASE, and VINEGAR (RADICAL). We proceed here to describe another method of concentrating vinegar, by which indeed it cannot be so much dephlegmated as by the preceding methods, but it is much more simple, and has some peculiar advantages. The method is effected by congelation, or freezing.

Stahl seems to be the first who employed this method. Since which time Mr. Geoffroy has made many experiments on this subject, a relation of which is to be found in the Memoirs of the Academy for the year 1739.

As acids resist congelation much more than water, if vinegar be exposed to a cold sufficient to sink the mercury of Mr. Reaumur's thermometer eight or ten degrees below the figure 0, a considerable quantity of ice will be formed. This ice, being separated from the rest of the unfrozen liquor, consists of scarcely any thing but pure water, and the unfrozen liquor is a much stronger vinegar. By exposing again this vinegar to another and stronger frost, more ice is formed in it, less hard than the first ice, and somewhat resembling snow, because it contains a certain quantity of unfrozen acid; and may therefore be set aside for the extraction of this acid. The acid remaining after the second congelation is greatly stronger. This concentration of vinegar may be much increased by repeating the congelation with greater cold. Mr. Geoffroy relates in the quoted memoir, that vinegar which has been already concentrated by frosts of preceding years, and eight pints of which had been reduced to two pints and a half by the frost of January 29, 1739, was at length so much concentrated, that two drams of this vinegar, the saturation of which before these concentrations would have required six grains of salt of tartar, did now require forty-four grains for that purpose.

Stahl assures us, that wine may be well concentrated by the same method. He says, that he exposed to frost different kinds of wine, and that he had procured by this means two thirds, or three quarters of pure phlegm.

Wines thus concentrated had a thick consistence, were very strong, and were preserved without change many years, in places, where the free access of air alternately hot and cold, according to the seasons, would have soured or spoiled any other wine in a few weeks. The general opinion that wines are spoiled and entirely weakened by frost proceeds undoubtedly from the ice not being taken

taken off, but left to mix again with the wine when it thaws. Perhaps also some delicate wines are considerably altered by frost.

Wallerius says, that in the northern countries cold is successfully used to concentrate sea-water, and to approximate the particles of salt, by separating the ice as soon as it is formed, and which is little else but pure water.

We might be induced to believe that the mineral acids might be concentrated by congelation, as indeed they might be, if they were mixed with a very great quantity of water: but their adhesion to water is so strong, that they cannot be much concentrated by this method.

**CXCII. CONDENSATION.** By the condensation of a body we ought to understand the approximation of its integrant parts, so that it occupies a smaller space, and that its specific gravity is augmented, without the loss of any heterogeneous matter. For instance, air, forced by compression to confine itself within a narrower space, is to be considered as condensed.

**CXCIII. CONE.** (x)

**CXCIV. CONTRAYERVA.** (y)

**CXCV. COPAL.** (z)

**CXCVI. COPPER.** Copper, called also by chemists *Venus*, is an imperfect metal of a red shining color. It is harder, more elastic and sonorous, but a little less ductile than silver. It is nevertheless considerably ductile, and may be drawn into wire as fine as hair, or beaten into leaves almost as thin as those of silver.

The tenacity of the parts of this metal is very considerable, since a copper wire, the diameter of which is a tenth part of an inch, is capable of supporting a weight of  $299\frac{1}{2}$  pounds without breaking.

(x) **CONE (MELTING).** This is a hollow cone formed of copper or of brass, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to rest. Its use is to receive a mass of one or more metals melted together and poured into it. This mass when cold may be easily shook out of the cone, from the figure of the vessel. Also if a melted mass, consisting of two or more metals, or other substances not combined together, be poured into this vessel, its figure facilitates the separation of these substances according to their respective densities. The cone ought to be well heated before the melted mass is poured into it, that no moisture may be contained, by which a dangerous explosion might be occasioned. It ought also to be greased internally with tallow, to prevent the adhesion of the fluid matter.

(y) **CONTRAYERVA.** The leaves of this plant are said to afford a poison employed by Indians for poisoning arrows, to which poison the root of the said plant is said to be an antidote. From an ounce of the root

Neuman extracted, with water, three drams and half a scruple; and from the same quantity, with spirit of wine, five scruples and two grains.

(z) **COPAL**, improperly called *gum opal*, is a hard, shining, transparent, citron-colored, odoriferous, concrete juice of an American tree, but which has neither the solubility in water common to gums, nor the solubility in spirit of wine common to resins, at least in any considerable degree. By these properties it resembles amber. By digestion in linseed oil, with a heat very little less than sufficient to boil or decompose the oil, it may be dissolved. This solution, diluted with spirit of turpentine, forms a beautiful transparent varnish, which, when properly applied, and slowly dried, is very hard and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colors of old pictures by filling up the cracks, and rendering the surfaces capable of reflecting light more uniformly.

Copper

Copper weighed by the hydrostatical balance loses in water about an eighth or a ninth part of its weight (*a*). It has a very singular and disagreeable smell and taste. It cannot be fused without a violent degree of heat sufficient to make it white.

Copper, being an imperfect metal, may be burnt, destroyed, and calcined by the united action of fire and air: for which reason its quantity is always diminished by melting it without covering its surface.

When it is exposed to a great fire with free access of air, it smokes, loses part of its weight, and communicates to flame beautiful green and blue colors.

It resists more than any other imperfect metal the action of fire before it suffers any considerable alteration. When a clean and polished copper plate is gently and gradually heated, its surface is covered with all the colors of the rainbow. This appearance proceeds from the developement, and the different states of the phlogiston of the metal. (*b*)

When this metal is exposed to red heat with contact of air, its surface becomes quickly tarnished, and its metallic lustre is changed into a dark and earthy appearance; and if this heat be continued during a certain time, the surface of the metal is burnt and destroyed; so that when it cools, it is found to have no longer any adhesion with the uncalcined copper, but to be separated in scales from the difference of the contraction, occasioned by cooling, upon the uncalcined copper, and upon its burnt surface.

When this surface is separated, the copper beneath it seems clean and shining; but it will soon suffer the same change as the former, if it be again heated; and thus a piece of copper may be entirely reduced to scales no longer possessed of brilliancy, ductility, or other metallic properties, and which are called *burnt copper*.

This calcined copper is less fusible than copper in its metallic state: when exposed to a great fire, but a very small quantity of copper is obtained from it; the rest of it is changed into a dark and opaque vitrified stria; except the scales have been mixed with some matter capable of restoring to them phlogiston; in which latter case a quantity of malleable copper is obtained nearly equal to that of the scales employed. See REDUCTION of METALS.

These copper scales, which are at first but imperfectly calcined, may be entirely deprived of phlogiston and of their metallic properties by a second calcination under a muffle continued sufficiently long.

(*a*) The specific gravity of European copper is to that of water as 8843, and of Japanese copper as 9000 to 1000.

(*b*) All metals are subject to receive these colors or irises by heat; and from the color of any part of a piece of metal we may discover what degree of heat has been applied to that part, as the same degree of heat always gives the same color to the same metal: hence artists, by observing the colors acquired by steel exposed to fire, are enabled to apply to pieces of that metal the precise degree of

heat which they have found by experience to produce the required hardness, in the operation of tempering steel. Thus they know, that the heat which gives a blue color to steel is sufficient to give the requisite hardness for springs. The irises, or different colors given to different parts of one piece of metal, are occasioned by the heat being unequally applied. These colors are produced by a more or less perfect calcination of the surface of the metal exposed to heat.

Copper is also affected by the combined action of air and water : hence its surface is apt to tarnish, and even to be covered with a green rust, called *verdegrise*.

This rust is copper partly decomposed, and deprived of part of its inflammable principle ; for it cannot be melted into copper without much loss, excepting its phlogiston be restored by some reductive flux. These are alterations to which all the imperfect metals are subject. See METALS (IMPERFECT).

This metal is easily soluble by all acids, and its solutions are green or blue. (c)

Vitriolic acid, although the strongest of all, dissolves copper more difficultly than any other : it must be concentrated and assisted by considerable heat and time to dissolve this metal. From this solution results a neutral salt, which forms beautiful blue crystals, called *blue vitriol*, or *vitriol of copper*. See these words.

Nitrous acid dissolves copper very quickly with violence and effervescence ; and during the solution it takes from the metal part of its phlogiston. The nitre formed by this solution is a very deliquescent salt. The salts formed by marine acid or by aqua regia with copper are also very deliquescent.

Vegetable acids, and particularly those of wine and of vinegar, may be easily united with copper. The former acid forms with it the verdegrise used in painting (See VERDEGRISE) ; and the second, when saturated, forms the salt called *crystals of verdegrise*, or *crystal of Venus*. See CRYSTALS of VERDEGRISE.

All acids united with copper may be separated from it without any intermediate substance, and merely by fire.

Calcareous earths, fixed and volatile alkalis, separate copper from any acid, and precipitate it in form of a beautiful green powder. The color of these precipitates of copper is caused by a portion of the salts which remain united with them. As the metal thus dissolved and precipitated has lost part of its phlogiston, particularly when it has been dissolved by vitriolic and nitrous acids, these precipitates of copper cannot be melted into malleable copper without addition of phlogiston : but if they be melted with glasses, or vitrescible matters, and the fire be properly managed, they communicate their colors to these substances : hence they may be applied to imitate precious stones of a green color, or nearly green, as the emerald, and beryl or aqua marina, and for several shades of painting upon pottery and porcelain.

Some metallic matters, which have a stronger affinity than copper has to acids, are therefore capable of precipitating this metal from its several solutions. Iron particularly has this property ; for which reason, if it be added to a saturated solution of copper in an acid, it will be attracted and dissolved by this acid, and it will precipitate the copper ; and thus the solution of copper is changed into a solution of iron. While this happens, a remarkable phenomenon appears : the copper thus precipitated is in its metallic state and brilliancy. This effect, which seems to be general whenever a metallic matter is separated from an acid by means of another metallic matter, can only happen because the

(c) Solutions of copper in vitriolic acid, vegetable acid, oil, or water, are green ; that in marine acid is at first brown or yellow, and becomes afterwards green ; and that in aqua fortis is of a bluish-green color : volatile or fixed alkalis make the solutions of copper in acids blue : a solution of copper in volatile alkali, exposed to air, is blue.

precipitating metal separates entirely and exactly all the acid from the precipitated metal, which earths and alkalis seem incapable of doing; and because the precipitating metal supplies enough of phlogiston to the acid, to prevent the acid from retaining the phlogiston of the precipitated metal, which earths and alkalis are also incapable of doing.

However that be, this precipitation of copper in its metallic state, by the intervention of iron, is capable of imposing upon, and actually has imposed upon persons ignorant of chemistry; who, perceiving that a piece of iron, dipt into a liquor in which they suspected no copper, became covered over with copper, imagined that this liquor had the property of changing iron into copper.

This property which iron has of separating copper from acids has been applied to use. In England, the water in a copper mine is impregnated with a great quantity of blue vitriol, and from which much copper is extracted by means of iron immersed in it. In Germany some copper ores are so pyritous, that they cannot be advantageously treated by ordinary fusions, but are reduced into vitriol, and by means of the iron which is put into the lixivium of this vitriol, called *cement water*, a considerable quantity of copper is obtained, which would otherwise be lost. See ORES, PYRITES, and VITRIOLS.

Copper produces, with respect to mercury and silver dissolved in acids, the same effects which itself suffers from iron; that is, it separates these metals so exactly from the acids with which they are united, that they appear with their metallic lustre.

This property of copper is employed to obtain silver dissolved by spirit of nitre in the operation of parting. This silver is generally very pure.

If a very clean plate of copper be immersed in a solution of mercury, particularly if this solution have an excess of acid, it will be very soon covered over with mercury, which adheres to it, and which, when wiped and washed, makes a very white and brilliant silvering. This also is one of the experiments which exhibit an appearance of transmutation capable of astonishing those who are ignorant of chemistry. Every day credulous persons are deceived by tricks no better than this.

No metal is more soluble than copper. It is acted upon by almost all saline and metallic substances, and probably for this reason ancient chemists have called it *Venus*, considering it as prostituted to all substances.

Fixed and volatile alkalis easily dissolve copper, either directly, or still better if it has been previously dissolved in acids. See ALKALIS (FIXED and VOLATILE).

Most neutral salts corrode its surface, and reduce it into verdigrise. The same effect is produced by all oils and fat matters, from the latent acid which they contain.

Sulphur has considerable action upon copper, and even has a greater affinity with it than with any other metal excepting iron: hence it may be separated from almost all metals by means of sulphur, which also renders it much more fusible. Copper is formed into a mineral or pyritous state by union with sulphur; and if this compound be exposed to fire, so that the sulphur shall be burnt, its acid will act upon the copper, and reduce it to blue vitriol.

Copper may be easily united with all metals and semimetals, and with them forms alloys; of which ~~for~~ the detail at the articles ALLAY, BRONZE, TOMBAC, and SIMILOR.

As this metal is combustible, it may be separated from the perfect metals by calcination, which is accelerated by means of lead, as in refining; or by nitre, which generally much accelerates the calcination of all combustible bodies; so that by repeated projections of nitre upon melted gold and silver allayed with copper, the nitre burns the phlogiston of the copper, and reduces this metal into a scoria which floats upon its surface: but the nitre must be added gradually, and but a little at a time, particularly if much copper be in the allay, because the detonation which it occasions is sufficient to dissipate some of the perfect metals. *See* NITRE.

The affinities of copper, according to Mr. Geoffroy, are mercury and lapis ilaminaris, or rather zinc; and according to Mr. Gellert, gold and silver. (*d*)

CXCVII. COPPER (WHITE). White copper is an allay of copper, zinc, and arsenic, in certain proportions, and is white as silver. The precise proportions cannot be easily determined, and the allay cannot without difficulty be made, because of the volatility of the two semimetals. Nevertheless, a very beautiful and silver-like white copper is made by some artists, who carefully conceal their method of preparation.

As this allay is not much used, from its very noxious quality, chemists have not considered it; otherwise any of them who knew the management of metals might probably discover it.

The medicinal virtues of copper are treated of under the article BRASS.

CXCVIII. CORAL (*e*)

CXCIX. CORK (*f*)

CC. CORK (FOSSIL). (*g*)

CCI. CREAM. This name is applicable to all substances which separate from a liquor, and collect upon its surface; but it is particularly given to the following substances:

(*d*) Wallerius says, that if a mixture of calx of copper and sal ammoniac be exposed during a certain time to air, from that mass, by distillation with soap, mercury may be obtained; whence he infers, that either mercury is a component principle of copper, or that at least some part of the copper is convertible into it.

(*e*) CORAL and CORALLINE are shells of marine animals of the polypus kind, and possess the same chemical properties as the fresh shells of oysters and other shell-fish, that is, they are calcareous earths impregnated with some animal principles. *See* EARTHS (CALCAREOUS). From sixteen ounces of coral, Neuman obtained by distillation six scruples of a volatile, alkaline, oily spirit, two or three grains of empyreumatic oil, and a residuum containing five

scruples and a half of fixed salt, probably sea-salt. The quantities of these component parts were found to vary according to the freshness of the coral analysed.

(*f*) CORK is the bark of a tree of the oak kind, which grows in the southern parts of Europe. From an ounce of cork Neuman extracted, by boiling in water, two scruples; and from the same quantity he obtained, by digestion in spirit of wine, two scruples and two grains.

(*g*) CORK (FOSSIL), *Suher montanum*. This name is given to a stone which is a species of amianthus, consisting of flexible fibres loosely interwoven, and somewhat resembling vegetable cork. This is the lightest of all stones. By fire it is fusible, and forms a black glass. It possesses the general properties of amianthus. *See* AMIANTHUS.

CCII. CREAM of LIME. The cream of lime is that most attenuated part of quicklime, and most approaching to a saline state, which is dissolved by water with which quicklime is slaked, or even in which slaked lime is boiled. This matter separates from lime-water by crystallization during the evaporation of the water; and as water only evaporates at its surface, this earthy crystallization is also formed there. It forms a semi-transparent pellicle, which becomes thicker and thicker till it separates into pieces, and falls to the bottom by its weight in form of scales. The cream of lime has the same properties as slaked lime has. See QUICKLIME. (b)

CCIII. CREAM of MILK. This is the most oily part of milk; which being naturally only mixed, and not dissolved in milk, and being specifically lighter than the other parts, separates from them by rest, and collects on the surface of the milk, from which it is generally skimmed to complete the disengagement of the oily from the caseous and serous parts, that is, to make it into butter. See BUTTER and MILK.

Cream of milk, which is generally called simply *cream*, is not only an agreeable aliment when recent, but is also useful in medicine as a lenient, when applied to tetters and erisipelas accompanied with pain, and proceeding from an acid humor.

CCIV. CREAM of TARTAR. Cream of tartar is, properly speaking, that part of the concrete acid of tartar which crystallizes first, and like a pellicle on the surface of water in which tartar has been boiled, with intention to purify it, and to separate from it its most saline part. Thus this substance called *cream*, from its manner of formation, does not essentially differ from the crystals of tartar which are formed in the liquor; and these crystals are accordingly, as well as the saline pellicle, generally called cream of tartar, these two matters being confounded together by one name, from which no inconvenience results. See TARTAR.

CCV. CRIMSON. (i)

CCVI. CROCUS. This Latin word, signifying *saffron*, has been applied as a name to earths of certain metals, which in color somewhat resemble saffron: such particularly are the earths of iron and of copper, each of which is therefore called *crocus*, the first being the *crocus of mars* or of iron, and the second the *crocus of copper*: but the word *saffron* is more commonly employed, and particularly applied to the earth of iron. See SAFFRON.

CCVII. CRUCIBLE. (A)

(b) Cream of lime is very different from slake quicklime. The latter substance is calcareous earth deprived of fixable air, and combined with water: it is caustic, soluble in water, and possesses all the properties of quicklime, from which it differs only in containing a quantity of water. Cream of lime is calcareous earth, which having been deprived of fixable air by calcination, and dissolved by water, is, by exposure to air, again combined with fixable air; by which

it is rendered mild, crystallizable, insoluble in water, and restored to its original state before calcination. See AIR (FIXABLE).

(i) CRIMSON. A crimson color may be given to silks and woollen cloths by cochineal. See COCHINEAL. A less durable crimson may be given by Brazil wood. For the color called by dyers *dead crimson*, the root of madder is mixed with cochineal. See RED and DYING.

(A) See POTTERY.

CCVIII.



CCVIII. C R Y S T A L. Crystal, called also *rock-crystal*, or *natural crystal*, is a hard, transparent stone, of the figure of a prism with six faces, which is terminated at each of its extremities by hexagonal pyramids.

The most beautiful rock-crystal is that which is perfectly clear, white, and transparent. It is frequently cut; and lustres, vases, and toys are made of it, as of other beautiful stones. Rock-crystals, like the precious stones, are of all colors; and they receive their color, as the precious stones do, from metallic and phlogistic substances. Some of them are brown, and almost black; these may be rendered white and transparent, by making them red-hot, which must be done very gently and gradually, to prevent their cracking, which they are very apt to do as well as other vitrifiable stones. See EARTH (VITRIFIABLE). (1)

(1) *Crystal, rock crystal, or quartz-crystal*, is a transparent stone of the class of earths called by some siliceous, and by others vitrifiable. Its form is that of an hexagonal prism, one of both ends of which are terminated by hexagonal pyramids. Some of them consist of these two pyramids joined together at their bases, without any prism interposed. Crystal is frequently found adhering to quartz; and, according to Cronstedt, it is nothing but quartz, which he affirms always assumes this hexagonal form, when its accretion or crystallization has not been interrupted. Crystals are either colorless, or colored. Colored crystals are called by some authors *fluors*. Those which are red are called *false rubies*; the violet-colored, *false amethysts*, or, according to Cronstedt, the *true amethysts*; the yellowish-red, *false hyacinths*; the blue, *false sapphires*; yellow, *false topazes*; the greenish-yellow, *false chrysolites*; the green, *false emeralds*; the sea-green, *false beryls*. Some crystals are dusky, brown, or blackish, but still transparent. Crystals possess the general properties of the earths called vitrifiable. See EARTH (VITRIFIABLE). Colorless crystals resist the most violent and long continued fire. See Mr. D'ARCY's *Account upon Vitification*, Academy of Sciences, 1766. Most of the colored crystals are fusible by violent fire. They probably receive this fusibility, as well as their color, from metallic substances. Colorless crystals may be tinged with various colors, so as to imitate precious stones. For this purpose, Neri, in his *Art of making Glass*, directs that pieces of clear crystal should be laid upon a mixture of four parts of orpiment, four parts of crude antimony, and one part of sal ammoniac, placed in a cru-

cible, to which another crucible inverted is well luted: the crucibles are to be placed in a furnace, and surrounded with charcoal: after a red heat has been gradually applied, and the fire extinguished, the upper pieces of crystal will have acquired a fine golden color, resembling opals, and variegated with beautiful spots: the lower pieces of crystal will have acquired a fine color, resembling that of the skins of vipers. He gives another process, in which he directs the cementing mixture to be composed of two parts of yellow orpiment, two parts of white arsenic, one part of crude antimony, and one part of sal ammoniac. He directs also, that no bellows or strong current of air should be applied to the fire, by which he says, that the crystals are apt to be cracked, probably by making the heat too intense, and that the crucibles should not be opened till they have been gradually cooled. Crystals thus treated resemble rubies, opals, agates, turquois, marbles, chrysolites. Mr. Pott says, that he found the color of some crystals much improved by repeating the operation. Baptista Porta directs, that crystals should be colored by keeping them immersed during four or five hours in a melted mixture of sulphur, crude antimony, orpiment, arsenic, and tutty. In these operations, the crystals seem to imbibe some of the vapors of the metallic substances. The chief difficulties seem to be to prevent the cracks to which the crystals are very subject by this treatment, and to procure a sufficient penetration. Probably both these purposes might be effected by a very strict attention to the gradual application, and to the maintenance of a due degree of heat.

CCIX. CRYSTAL (FACTITIOUS). The word crystal has been applied to glasses produced by art, which from their transparency and whiteness imitate rock-crystal. In fact, some are made as beautiful as the finest rock-crystals, but not nearly so hard. The heat of ordinary vitrification seems incapable of producing glass as hard as rock crystal; nor do our crucibles seem capable of sustaining the requisite heat, if it could be raised. *See the method of making crystals at the words GLASS and VITRIFICATION.*

CCX. CRYSTAL (MINERAL). Mineral crystal, called also *Salt of Prunella*, is melted nitre detonated with a little sulphur, and cast into form of tablets.

Nitre is one of the neutral salts which contains the least water in its crystallization, or which loses the least water by a true fusion, and is also one of the most fusible salts.

To make mineral crystal, very pure nitre must be put into a clean crucible, and quickly fused, taking care that no ashes or coal fall in. When the nitre is fused, it is to be detonated with sulphur, in the proportion of a dram of the latter to a pound of the former. It is then to be poured into a copper, or rather a silver basin, in which it is to be agitated while yet fluid, that it may fix in form of cakes or tablets.

No other effect is produced upon the nitre by the small quantity of sulphur with which it is detonated, than to introduce into it a proportionable quantity of vitriolated tartar, called *Sal Polychrest of Glasser*. In all other respects, chemical and medicinal, mineral crystal is nitre, and may be given like this, from four grains to ten or twelve, in a quart of proper drink. It is cooling, sedative, aperitive and diuretic. This preparation then seems useless, since the same intentions may be better accomplished by well purified nitre. *See NITRE.*

CCXI. CRYSTALLIZATION. This word is sometimes employed to signify substances which are crystallized, or whose parts are so arranged that they form regular figures. In this sense, we say *stony crystallizations, pyritous crystallization, &c.*

CCXII. CRYSTALLIZATION of SALTS and of other Substances. If the word crystallization were to be confined to its most proper sense, as it seems to have been formerly, it could only be applied to operations by which certain substances are disposed to pass from a fluid to a solid state by the union of their parts, which so arrange themselves that they form transparent and regularly figured masses, like native crystal; from which resemblance the word crystallization has evidently been taken.

But modern chemists and naturalists have much extended this expression, and it now signifies a regular arrangement of the parts of any body which is capable of it, whether the masses so arranged be transparent or not. Thus opaque stones, pyrites, and minerals, when regularly formed, are said to be crystallized, as well as transparent stones and salts.

The opacity and transparency of substances are justly disregarded in considering whether they be crystallized or not; for these qualities are perfectly indifferent to the regular arrangement of the integrant parts of substances, which is the essential object of crystallization.

This being established, crystallization ought to be defined an operation by which the integrant parts of a body, separated from each other by the interposition

sition of a fluid, are disposed to unite again and to form solid, regular, and uniform masses.

To understand as much as we can of the mechanism of crystallization, we must remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obstacle.

2. That in simple, or little-compounded bodies, this tendency of integrant parts is more obvious and sensible than in other more compounded: hence the former are much more disposed to crystallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that the primitive integrant molecules of every different body have a constantly uniform and peculiar figure.

4. That these integrant parts cannot have an equal tendency to unite indiscriminately by any of their sides, but by some preferably to others, excepting all the sides of an integrant part of a body be equal and similar; and probably the sides, by which they tend to unite, are those by which they can touch most extensively and immediately. The most general phenomena of crystallization may be conceived in the following manner.

Let a body be supposed to have its integrant parts separated from each other by some fluid. If a part of this fluid be taken away, these integrant parts will approach together; and as the quantity of intervening fluid diminishes, they will at last touch and unite. They may also unite, when they come so near to each other that their mutual tendency shall be capable to overcome the distance betwixt them. If, besides, they have time and liberty to unite with each other by the sides most disposed to this union, they will form masses of a figure constantly uniform and similar. For the same reason; when the interposed fluid is hastily taken away, so that the integrant parts shall be approximated, and be brought into contact before they have taken the position of their natural tendency, then they will join confusedly by such sides as chance presents to them; they will in such circumstances form solid masses, whose figures will not be determinate, but irregular and various.

In every crystallization all that we have described may be observed.

If crystallization be taken in the general sense we have given to it, ice is a true crystallization. Water, for instance, is to be considered as a body whose integrant parts are separated from each other by the interposition of the matter of fire. Melted metals are also to be considered in the same manner. The fluidity of these bodies is to be attributed to this matter of fire, with which these bodies are penetrated. When therefore these liquefied bodies cool, which can only be by taking away this igneous matter which penetrates them; if the approximation of the integrant parts, which is a necessary consequence of this cooling, be made so slowly that they shall have time and liberty to unite by the sides most disposed to this union, they will always form masses of a constant and similar figure.

Thus when water freezes slowly, and is not agitated by any motion which can disturb the order in which the integrant parts tend to unite, it forms regular crystals of ice, and always of the same form.

These

These crystals which may be called crystals of water, are long, needle like masses, flattened on one side, joined together in such a manner that the smaller are inserted into the sides of the greater; and thus these compound crystals have the appearance of feathers, or of leaves of trees.

The most remarkable circumstance attending this crystallization is, that the angle formed by the insertion of the smaller needles into the sides of the larger ones is always of the same width, that is, sixty degrees. However, it is sometimes double, that is, 120 degrees; but it is constantly one of these two angles, and it is to be remembered that these angles are complements to each other, that is, they are together equal to two right angles. We are obliged to Mr. Mairan for these fine observations, which he has given at full length in an excellent dissertation on ice.

Metal, sulphur, and several other bodies not much compounded, which fix and become solid after fusion, assume always a regular arrangement whenever they are slowly enough cooled for that purpose. The star of the regulus of antimony has been long observed with wonder. Alchemists, who saw wonders in all their operations, considered this star as something mysterious and significant; but the wonder ceased when the cause of it was investigated by so good a philosopher as Mr. Reaumur, and discovered to be the tendency which the integrant parts of the regulus of antimony have to arrange themselves in an uniform manner; for this arrangement always happens, when the regulus of antimony has been well fused, and slowly cooled. Mr. Macquer and Mr. Beaumé having fused silver with great heat, and afterwards very slowly cooled it, observed that this metal also arranged itself in a regular manner. Mr. Beaumé observed the same effect upon applying to all the other metals and semi-metals the same treatment. Every metallic substance was found to have its peculiar form, which Mr. Beaumé proposes to determine.

What we have said concerning bodies, which being fused by fire, are crystallized when they become solid by cold, may also be applied to all those whose integrant parts swim separately from each other in a fluid such as water. Thus all kinds of earths, and of metallic and mineral matters, which are found in that state, may be crystallized by taking away some of the watery fluid which separates their integrant parts. A slow evaporation of the water which contains these substances allows their parts to approximate and to unite together by the most suitable sides, and to form masses of a determinate and constant figure.

In this manner are formed the crystallizations of precious stones, of rock crystal, of spars, of certain stalactites, and of all stony bodies found so frequently well crystallized. The regular forms of most pyrites, of many ores and metallic minerals, and even of some pure metals, such as gold, silver, copper, which are found regularly arranged and ramified, ought to be attributed to the same mechanism, that is, to the slow separation of their integrant parts from the water in which they are suspended.

But of all the substances thus susceptible of crystallizing by their separation from water, salts are most disposed to it, and afford the best examples of crystallization; because all saline substances being essentially soluble in water, are liquefied by this fluid in a much greater quantity than the bodies we have mentioned, which, properly speaking, are only miscible with water.

This

This property which salts have of being soluble by water must depend on a certain affinity or adhesion of their integrant parts to those of water; and from this adhesion we can deduce the phenomena peculiar to the crystallization of salts, and the differences observable betwixt the crystallization of these, and that of other substances to which water has not the same affinity. We shall relate what is most necessary to be known concerning the crystallization of salts, an object of great importance in chemistry.

The crystallization of a salt dissolved in water may be procured, as evidently appears from what we have said, by taking away the dissolving water: and as most salts are less volatile than water, and may even be considered comparatively as fixed substances, this subtraction may be commodiously made by the evaporation of a sufficient quantity of water. The parts of the salt, being sufficiently approximated by this evaporation, will unite together and form crystals, as we have already explained concerning other substances. But as the saline parts adhere to those of the water, this circumstance occasions an essential difference in the crystallization; which is, that the salt when crystallizing, does not separate itself from all the water with which it was united in solution, but retains some part of it with some force; and this portion of water adhering to, and even combined with the parts of salt, makes with it one whole or entire body; whence saline crystals are compounded of crystallized salt, and of water which makes part of these crystals. This water is called by chemists the *water of crystallization*.

As this water of crystallization is superabundant to the essence of the crystallized salt, it may be taken from it by evaporation with a certain degree of heat, without any change produced upon the essential properties of the salt; so that it may be again dissolved and crystallized as at first. But we must observe, that the water of crystallization cannot be taken from any salt without destroying the form, or at least the consistence and transparency of the crystals; and when the salt is to be re-dissolved and re-crystallized, it retains in this second crystallization the same quantity of water precisely as it had in the first.

Hence we ought to conclude that this water of crystallization is not essential to a salt, as a salt, but that it is essential to a salt as being crystallized; since to it the saline crystals owe their form, transparency, and even the cohesion of their parts.

The quantity of water of crystallization varies much in different salts. Some of these, as alum, Glauber's salt, and martial vitriol, contain about half their weight of water; and others, as nitre and sea salt, contain but a small quantity. Selenites contains an almost insensible quantity of water. This difference seems to depend on the state of the acid in these salts; and in general the more firmly an acid is combined with its basis, the less water it retains in crystallization.

A very important remark to be made upon this water of crystallization, is, that when the crystallization is properly managed, this water is perfectly pure, and contains no substance foreign to the crystallized salt. To Mr. Beaumé we owe this discovery. By many experiments he was convinced that no neutral salt, with a basis of fixed alkali, retains in its crystals either superabundant acid or alkali, or any other matter foreign to the neutral salt, although even this

salt had been crystallized in a liquor that was acid, alkaline, or impregnated with any other substance foreign to the salt; and that if sometimes these heterogeneous substances are found included in saline crystals, they have no adhesion to them, since they may be separated merely by draining upon brown paper, without any change produced upon the crystals of the salt; whereas the water of crystallization cannot be taken away without a destruction of the crystals. The cause of this phenomenon will easily appear when we recollect that salts retain the water of their crystallization by the adhesion of these salts to water; and that if a salt be dissolved in water impregnated with acid, alkali, or other substance foreign or superabundant to the salt dissolved, this salt does not adhere either to the superabundant acid, or alkali, nor to the other extraneous substances, but to the water alone.

Evaporation of water, in which a salt is dissolved, is not the only method by which the salt can be crystallized. Another method which may be used with success, at least for the crystallization of most salts, is by application of cold to the water suspending the salt. The reason of this is as follows.

All salts are soluble in water, but not with equal facility, some of them requiring much water, and others very little: most of them are more easily dissolved, and in greater quantity, by hot than by cold water; and others with nearly equal facility, and in equal quantity by both hot and cold water. This being established, when boiling water, that is, water heated as much as possible, suspends in solution all that it can dissolve of those salts which are more soluble by hot than by cold water, if this water be cooled, the portion of salt which was dissolved merely by the heat of the water, will be collected and crystallized as fast as the water cools. We may also observe, that when this cooling of the water is very quick, the crystals it occasions are small, irregular, and ill-shaped; and that the more slowly the cooling is produced, the larger and better formed the crystals are.

What has been hitherto said concerning the regular forms taken by certain liquefied matters during their fixing or becoming solid, is entirely applicable to this kind of crystallization of salts. This crystallization is not effected by a subtraction of water but of fire, by which subtraction a condensation of the saline liquor is produced, and consequently a sufficient approximation of the parts of the dissolved salt to dispose them to unite, and to form crystals; and as in this case, the fluidity or the solidity of the salt is solely occasioned by the presence or absence of the matter of fire, these salts dissolved by heat, and crystallized by cold, may be compared to melted metals, the parts of which are regularly arranged by a slow cooling. But with regard to salts we must observe, that at their crystallization is performed in a fluid to which they have an adhesion, they retain the same quantity of water of crystallization, whether the operation was performed by cold or by evaporation.

Hence we may perceive, that evaporation and cooling are the two principal methods of crystallizing salts. Sometimes it is proper to employ one only of these methods, and at other times both together, according to the particular nature of the salt to be treated. If it be one of those salts which are better crystallized by cooling than by evaporation, such as nitre, for instance, then the former method ought to be used; for nitre cannot be well crystallized by  
 evapo-

evaporation alone, because the water which keeps it dissolved would be reduced almost to nothing before the crystallization would begin, and the liquor would be so concentrated that the parts of the salt would not arrange themselves properly.

When, therefore, nitre is to be crystallized, the water is to be evaporated so far only that when it cools crystals shall be formed. This degree of evaporation is known by taking a few drops of the hot liquor, and cooling them quickly; if the evaporation has been sufficient, small crystals may be perceived instantly formed. As the evaporation here mentioned does not occasion the crystallization of the nitre, but is only preparatory to it, this evaporation may be either quick or slow without inconvenience. The liquor may be made to boil as fast as possible, and the crystals of nitre will be no less perfect, provided that this liquor when sufficiently evaporated be slowly cooled: when it is perfectly cooled, no more crystals will be formed in it. It ought then to be poured off, and again evaporated, when by a second cooling it will furnish more crystals, and this treatment is to be continued to the end.

But if well formed crystals are to be obtained of one of those salts which are nearly as soluble in cold as in boiling water, and which consequently cannot be crystallized by cold, evaporation is the only method to be used. Common salt is a proper instance of this kind.

Water impregnated with common salt must be evaporated to obtain crystals; and when the liquor contains much more water than is necessary to the solution of the salt, the evaporation may be carried on as fast as possible till the crystallization is ready to begin. This point is known by a thin, saline pellicle, which floats on the surface of the liquor, and seems as if dust had fallen upon it. This pellicle is composed of the first portions of salt beginning to crystallize. It is always formed at the surface; because this salt crystallizes by evaporation only, and evaporation is only at the surface.

Mr. Rouelle, in his Memoir concerning the Crystallization of Sea-salt, says, that he has observed, that when the evaporation has been very slow, and with a heat not much exceeding that of summer, the crystals of common salt are formed at the bottom and not at the surface of the liquor. As this appears quite contrary to the manner in which this salt crystallizes in all other circumstances, have we not reason to believe, that in this insensible evaporation the crystals of sea-salt are formed first at the surface, as in all other evaporations, but that they cannot be perceived from the extreme smallness of their size at first; and because the heat is too weak to dry their upper surface, and to make them adhere to the air, these small crystals fall to the bottom without being perceived, and there become larger by the union of other small crystals, formed and precipitated in the same manner?

If the evaporation when brought to the point of crystallization was to be stopt, and the liquor to be cooled after it has been filtrated, and put into a bottle to prevent further evaporation from the remaining heat, scarcely any crystals would be formed in it, but the salt would remain dissolved in the water. If, on the contrary, the evaporation should be hastily continued, salt would indeed be formed in great quantity; but as its parts would not have time to

arrange themselves properly, the crystals would be small and ill-formed \*. The evaporation therefore ought to be continued, but slowly: and by this method very beautiful crystals will be obtained, partly in cubes, partly in hollow pyramids formed by cubes †.

The rules of crystallization most suited to the nature of each salt must be observed, not merely to obtain well-formed crystals; for if their figure was once determined, the regularity of their crystallization would be afterwards of no consequence: but the crystallization of salts relates to an affair of much more importance, which is their purity.

We have already said, that, when a salt is well crystallized, the water of its crystallization is very pure, and contains none of the heterogeneous matters which happened to be mixed with the solution of the salt before crystallization. This observation may be extended to other salts which may happen to be dissolved in the same liquor. If then several salts be dissolved together, we may almost always separate them exactly from each other, by crystallizing each of them according to their character; for amongst the almost infinite number of salts now known, scarcely two show precisely similar phenomena in crystallization. We may, from the example of separating nitre and common salt when dissolved together in the same liquor by crystallization, show how such separation may be done in general, even when several salts happen to be so confounded. This is certainly one of the finest and most useful problems in chemistry.

Let us then suppose that nitre and sea-salt, dissolved in the same liquor, are to be separated from each other. The method of effecting this will appear evidently from considering what we have said concerning crystallization; and this method will be found to consist in employing alternately evaporation and cooling. First of all then, the liquor must be evaporated. If, during the evaporation, a pelticle appears on the surface, and no crystals of nitre appear in a small quantity of the liquor when hastily cooled, then we discover that common salt is in greater quantity than the nitre. In this case the evaporation must be continued, and the common salt separated as fast as it is formed, till a small quantity of the liquor, when hastily cooled, shews small needle-like crystals of

\* Although crystals of sea-salt are generally less regular when formed by a hasty than by a slow evaporation, this irregularity is, however, less sensible in this salt than in most others, and its crystals always tend to a cubic form, or at least appear composed of cubes. From this observation we have reason to believe that the primitive integrant molecules of this salt are cubes: hence we may conceive that as all the sides of this salt are equal and similar, from their union regular solids ought to result, more or less approaching to the cubic figure, by whatever side they may have been united. *Note of the Author.*

† Although in a moderate evaporation a very large quantity of crystals of common salt is formed in quadrangular, hollow, and inverted pyramids, the cubic figure is never-

theless the primitive and essential form of this salt; for these pyramids are all composed evidently of cubes. Besides, they are only formed accidentally, by the union of several quadrangular prisms composed of cubes, which are successively applied to the sides of a first cube; which being formed at the surface of the liquor, remains suspended there, by the adhesion of its upper dried surface to the air. As this cube is besides a little sunk into the liquor by its weight, so that the liquor rises along its sides, it becomes by that means a very proper foundation for the formation of this pyramid. This mechanism is explained at length in Junker's book, and in a Memoir of Mr. Rouelle concerning the crystallization of sea-salt, printed in 1745. *Note of the Author.*

nitre;



nitre; then the liquor is to be left to cool, that the nitre may have an opportunity of crystallizing by cooling; after which the evaporation is to be resumed that more common salt may be separated, and to dissipate so much water that crystals of nitre shall again be formed by cooling. Thus these salts may be alternately crystallized, one by cooling and the other by crystallization, till they are entirely separated.

If, in the beginning of the operation, the liquor had, upon trial in small quantity, given crystals of nitre by cooling, before any pellicle had appeared upon its surface, the common salt would then have been known to be in much less quantity than the nitre. In this case, the nitre would have been crystallized first, but always by cooling. The quantity of nitre, which exceeds that of common salt, having been thus separated, the common salt would then begin to crystallize in its turn by evaporation.

Several essential remarks are to be made upon this separation of several salts from each other by crystallization.

First, although the two salts, the method of separating which we have given as an example, are the most capable of such a separation, because sea-salt is one of the salts which are least of all to be crystallized by cooling; and on the contrary, nitre is one of those which are best crystallized by this method; nevertheless, after a first crystallization of these two salts, such as we have described, they are not entirely and perfectly separated from each other: the sea-salt contains some nitre, and the nitre contains some portion of sea-salt; because in crystallization one salt always takes with it a small portion of another: but when two salts are so different from each other in this respect as these two, a perfect separation may be easily made by dissolving each of them separately in more water, and by proceeding to their crystallization by the same method. As a new separation is made by each crystallization, they may be obtained at last perfectly pure by repeating sufficiently this management.

The second remark to be made on the separation of salts by crystallization is, that this separation is so much more difficult and long, in proportion as the salts to be separated are more similar to each other in their manners of crystallization. For instance, if two salts, which are only capable of crystallizing by evaporation, as sea-salt and vitriolated tartar, or by cooling, as nitre and Glauber's salt, they cannot be ever obtained quite pure and separated from each other by any management: nevertheless, even in this case they may be in great measure separated; first, because the precise degree of evaporation, or of cold, which is necessary for the crystallizing of one salt, is generally somewhat different from that which is requisite for the crystallization of another salt; secondly, because although they should resemble each other much in this respect, some differences, which must be observable in the size and form of their crystals when well formed, will furnish means of making at least an imperfect separation, which may be made more perfect by repeating this management.

But the separation of some salts is attended with singular and even insuperable difficulties. Such are the salts which have some action upon each other, and the parts of which have some adhesive power together. This action of neutral salts upon each other has been very little observed: it is, nevertheless, very sensible in some of them; such are sal ammoniac and corrosive sublimate, which not only act as intermediate substances to each other, by which they can be dissolved

dissolved in greater quantities in water and in spirit of wine than they can singly, but which being dissolved together in the same menstruum, cannot be again crystallized separately by any method; as Mr. Macquer has shewn in his Memoir concerning Mr. Garay's Tincture of Mercury, printed in the Collection of the Academy for the year 1755.

Some salts have so great affinity with water, and are so soluble by this menstruum, that they can scarcely be crystallized. The solution of these salts requires to be evaporated almost to dryness, or to a thick consistence, and then by cooling they generally form needle-like crystals applied longitudinally or transversely to each other. When they are exposed to the air, they attract humidity, and resolve into a liquid state. Mr. Rouelle was the first who described, in his Memoir concerning Salts in the year 1744, the crystallization of deliquescent salts, such as marine salt and nitre with bases of calcareous earth, of copper, and of iron, terra foliata tartari, and the salts formed by the union of the acids of vinegar and of tartar with iron and with copper.

All these so difficultly crystallizable salts may be easily separated from salts which may be readily crystallized, with which they happen to be mixed; because the former salts in the evaporations and coolings are always the last to crystallize.

Two of these salts, namely nitre and marine salt, with bases of calcareous earth, are found mixed with nitre and marine salt with bases of fixed alkali; both of them in the lixiviums of the manufacturers of nitre, and the latter in almost all the waters in which common salt is found to be naturally dissolved: hence, when the proper operations are made to obtain nitre and sea-salt, after all the evaporations and crystallizations, a very heavy saline liquor remains from which no crystals can be procured, called the *mother water*. These mother-waters of nitre and of common salt are, then, nothing but these salts with earthy bases almost pure; and if a crystallization of them were required, the method described by Mr. Rouelle in the quoted Memoir ought to be practised. But this is not a matter worthy the attention of the manufacturers, to whom the perfect purification of nitre and of sea-salt, from an adhering portion of the salts with earthy basis, is of much more importance, as we shall see when we shall treat of these salts.

Chemists have given much attention to this subject, the crystallization of salts; and particularly Mr. Rouelle has made many interesting researches concerning it, which may be seen in his Memoir of 1744. But nevertheless, much remains yet to be done. The true form of all crystallizable salts, and the best methods of crystallizing them, are not yet determined; which will not appear surprising to those who understand this subject, and who know that one and the same salt, although constantly tending to the same form, is nevertheless capable of disguising itself in many ways, and of taking many different forms, according to the circumstances during crystallization. The quickness or slowness of evaporation, the quantity of water evaporated, the more or less hasty cooling, and the different degrees of cold applied, the state of the air and of the liquor with respect to rest or motion, even the form and matter of the vessel in which a salt is crystallized, are so many causes, which, acting successively or together in many different ways, are capable of producing numberless varieties in the crystallization.

Of all the causes which we have mentioned, capable of varying crystallizations, the nature of the vessel employed seems to deserve least our attention; yet this may produce some change from the greater or less adhesion which the salt may have to the several matters of which these vessels are made. For instance, we can only attribute to the adhesion of salts to the sides of the vessels employed the property which most of them have to branch out in various manners; and to creep along the sides of these vessels, particularly when the crystallization is very slowly performed, so considerably that they frequently go even on the outside of the vessels. Mr. Beaumé has prevented this phenomenon by hindering the adhesion of the salts to the sides of the vessels, by rubbing these sides with some oil.

From what has been said concerning the action of neutral salts upon each other we may conceive, that when such salts happen to be mixed together, they must produce considerable differences in crystallizing.

Many other important observations might be made on the crystallization of certain salts, but they will be better placed under the articles of the several salts which they concern. We are obliged also to leave to the understanding and reflection of our readers to draw from what we have said many corollaries, the detail of which would be too long. We shall only mention a manner of crystallizing salts which is different from the methods by evaporation and by cooling, but which consists also in taking away from the salt a portion of water which keeps it dissolved. This method of crystallization is well effected by adding to a solution of a salt a sufficient quantity of a substance which has no action upon that salt, but which has greater affinity than it with the water which keeps it dissolved. Spirit of wine, for instance, has these properties with regard to many salts. Thus by adding a sufficient quantity of rectified spirit of wine to a strong solution of Glauber's salt, of vitriolated tartar, or of sea-salt, this spirit of wine seizing the water necessary for the solution of the salts, obliges them to crystallize immediately: but as this crystallization is very hastily made, and almost instantaneously, the crystals are always very small and ill-formed. In this respect they resemble the crystals of salts produced from a liquor which contained too little water to keep them dissolved. This happens, for instance, when a strong solution of alkaline salt is combined with concentrated vitriolic acid, to form vitriolated tartar; for this salt, which requires much water to keep it dissolved, does not find enough in the liquor, and appears immediately in form of very small crystals like sand. The same thing may be said of vitriols of silver and of mercury, of luna cornea, and of other metallic salts of this kind produced by adding vitriolic or marine acids to the white metals dissolved in nitrous acid. These salts appear immediately as precipitates, whenever they do not find water enough in the liquors to dissolve them; and Mr. Rouelle justly observes, in his Memoir, that they are not precipitates, but true salts, which not finding water sufficient for their solution, are obliged to be immediately crystallized, but in crystals so small, from the rapidity of their crystallization, that they cannot be known to be crystals but with the help of a microscope.

Notwithstanding what has been said concerning the irregularity of the crystals procured by adding a substance, which seizes the water of the solution of salts, yet if this addition was managed and gradually made, perhaps it might produce very beautiful and very regular crystals. Mr. Beaumé has actually observed,

that when salts were crystallized in acid or alkaline liquors according to their nature, their crystals were infinitely larger and more regular than they would have been without this circumstance. *Vegetable salt*, for instance, and *salt of Saignette*, require to be crystallized in an alkaline liquor; and *sedative salt* requires an acid liquor, when it is obtained from borax by the intervention of an acid, if we desire to have fine crystals of these salts. The cause of this must be, that acids or alkalis, having in general more affinity with water than neutral salts have, diminish the adhesion of these neutral salts with the water of the solution; for a too great adhesion of a salt to water may evidently be a great impediment to its crystallization. See the words SALT, SALTS (NEUTRAL), and the several sorts of neutral salts under their respective names.

CCXIII. CRYSTALS. All neutral salts with metallic bases susceptible of crystallization are commonly called by chemists *Crystals*, when they are actually crystallized; and the name of the metal contained in the salt is added to distinguish it. Thus we say, *crystals of gold, of silver, of copper, of lead, &c.* But as these names do not indicate the acid contained in each salt, they ought to be disused. Here we shall only mention two of these salts called crystals; because they are almost always distinguished by that name. These are the *crystals of silver*, and *crystals of verdigrise or of copper*.

CCXIV. CRYSTALS of SILVER, or LUNAR CRYSTALS. Crystals of silver are neutral salts with metallic bases composed of nitrous acid saturated with silver. When very pure silver is dissolved by very pure nitrous acid, if the acid be strong, crystals will be perceived merely by the cooling of the solution. These crystals are white, flattened like thin scales, and not very hard. When the nitrous acid used to dissolve the silver is weak, no crystals are formed; because the water in the acid is sufficient to keep the newly formed salt dissolved; but lunar crystals may easily be obtained from this dilute solution by evaporating the superabundant water, and letting the liquor cool.

Very beautiful and white lunar crystals may also be obtained, although the silver employed be alloyed with copper or iron: because the salts formed by these two metals with nitrous acid are deliquescent, and are not so easily crystallizable as the salt with basis of silver. In this case the solution ought to be evaporated, if it be necessary; and the crystals of silver will be crystallized by cooling, while the copper or iron will remain dissolved. When the colored liquor is poured off, crystals will be found sufficiently white and almost pure; but to purify them perfectly, they ought to be drained, dissolved again in very pure water, and again crystallized: then after they are well drained from the liquor, they will be found perfect and beautiful. This even is a method of separating silver from the alloy of copper, or of iron; and of obtaining from standard silver, or silver alloyed with copper, as fine and colorless a solution as if tested silver had been employed.

Lunar crystals then are a true *lunar nitre*, or *nitre with basis of silver*; and they accordingly have the property of deflagrating upon burning coals, almost as well as nitre, with basis of fixed alkali. When this experiment is made, silver is found after the detonation incrustated upon the surface of the coal in its metallic state.

Notwithstanding this property which lunar nitre has of detonating with coals, a property which shews a strong adhesion of nitrous acid with silver; yet this adhesion

adhesion is not sufficiently strong to resist a certain degree of heat; so that by calcination or distillation these two substances may be disjoined.

Lunar crystals may be melted with a very gentle, and less than a red heat. They easily lose the water of their crystallization, and then congeal into a black mass, which is generally cast into moulds, and is called *Lapis infernalis*, or *lunar caustic*. See CAUSTIC (LUNAR).

This salt is very caustic, as the effects of the lunar caustic shew in surgery, although it has lost a part of its acid in the fusion which it receives. This corrosive quality of lunar crystals seems to render it unfit for internal use as a medicine; yet some physicians prescribe it as a powerful evacuant of water. Boyle, though not a physician, but assisted by some persons of the faculty, proposes a method of rendering these crystals of silver milder, and boasts much of them as a remedy. His method consists in adding to a solution of them in water another solution of an equal quantity of nitre, and evaporating the whole to dryness and whiteness, with a very gentle fire, by which a portion of the spirit of nitre is intended to be taken away without fusing the saline mass; after which, this saline powder is to be made into pills, by forming it into a paste with some bread and water.

Little skill in chemistry is requisite to shew, that nitre thus mixed with lunar crystals, being incapable of acting upon it, cannot render it milder, but must leave it unchanged.

Secondly, by the manner of drying this mixture of lunar crystals and nitre, less of the causticity of these crystals is destroyed than by forming them into lunar caustic, in which operation they sustain a heat sufficient to fuse and to blacken them, and consequently lose more of their acid. After these considerations, we cannot believe that this remedy of Mr. Boyle is so mild and innocent as it has been represented. This is certain, that, notwithstanding the praises given it by this philosopher, its use has not yet been established in medicine.

Lunar crystals are called by Lemer *vitriol of silver*; but as they contain no vitriolic acid, this name does not suit them, and ought only to be given to the salt formed by the union of vitriolic acid with silver. See SILVER.

CCXV. CRYSTALS of COPPER, or of VENUS. By these names is meant a salt formed by the union of the acid of vinegar with copper.

This combination may be made by dissolving directly copper in good distilled vinegar; but it is made much more commodiously, and more expeditiously, when the copper employed has been previously formed into verdigrise; because the copper in the verdigrise is already divided and penetrated by a certain quantity of acid of wine: verdigrise therefore is always used for the preparation of crystals of copper.

This operation is very simple. It consists in dissolving verdigrise in good distilled vinegar till this acid be saturated. For this purpose a matraass is to be used, and to be set in a sand-bath with a gentle heat. When the vinegar dissolves the verdigrise, it takes a fine greenish-blue color. Some chemists call it also Tincture of Venus. When it ceases to act on the verdigrise, it is to be decanted, evaporated, and crystallized. The beautiful greenish-blue crystals formed are crystals of copper. When this salt is exposed to a dry air, it loses easily the water of its crystallization, and its surface is reduced to a lighter-colored tea-green powder.

The acid of vinegar does not strongly adhere to the copper in this combination. It may be entirely separated from it by distillation; and as it had lost most of its superabundant water when it united with the copper, it may by this method be obtained in its greatest concentration. It is called *radical vinegar*, and improperly *spirit of Venus*. See *these words*.

The principal intention of chemists in making crystals of Venus is to obtain radical vinegar. But this preparation is also used by painters; for which reason large quantities of it are manufactured, and it is generally sold under the name of *distilled verdegrise*; probably because distilled vinegar is employed in its composition. See COPPER and VINEGAR.

CCXVI. CUCURBIT. A cucurbit is a chemical vessel employed in distillation, when covered with its capital or head. Its name comes from its lengthened shape, by which it resembles a gourd: some cucurbits, however, are shallow and wide-mouthed. Cucurbits are made of copper, tin, glass, and stoneware, according to the nature of the substances to be distilled. A cucurbit provided with its capital constitutes the vessel for distillation called *Alambic*. See *this word*, and PLATES.

CCXVII. CUPEL. A cupel is a wide-mouthed earthen vessel, like a flat cup, from which resemblance it has been named.

The use of cupels is to contain gold and silver mixed with lead in the operations of refining and of assay, and to absorb the litharge and other scorified matters formed in these operations.

For this reason cupels ought to be made of dry, porous earths capable of resisting the action of strong fire, and of fluxes.

The ashes of wood and of bones are the most proper earths for cupels. These ashes ought to be perfectly burnt and calcined; that is, till they become white, so that they contain no more inflammable principle, which might revivify the scorified metals, and occasion an ebullition during the operation. They ought also to be well lixiviated, and deprived of all saline matter to avoid their fusion.

To form cupels, ashes thus prepared ought to be mixed with water into a paste, to which a proper form is given by means of a mould. Sometimes they are made into a paste with some beer; a small quantity of clay is added, that they may be moulded more conveniently. *Roasting tests* made of clay are also called by some artists *cupels*; because they have the same form as the refining and assay cupels. See ESSAY, and PLATES.

CCXVIII. CUPELLATION. Cupellation is an operation by which gold and silver are refined or assayed by scorification with lead upon the cupel. See REFINING and ESSAY.

## D.

CCXIX. **D** A M P S. These are noxious and even fatal exhalations or vapors, which infest subterranean places, and particularly mines, if the air be not frequently renewed.

The instances of fatal accidents caused by these vapors are too frequent. Most of them kill animals so suddenly that no assistance can be given.

Although all these vapors produce similar effects, and occasion sudden and mortal faintings and synopes, yet some differences may be observed in the properties and modes of acting of these vapors in different places. From which we may presume, that they are not all exactly of the same nature.

Some of them are visible, and appear in form of a fog: such is that which is found in a quarry near to the mineral waters of Pyrmont; and of which Dr. Scip has given a description in the *Philosophical Transactions*. This vapor has a sulphureous smell, destroys insects, birds, and in general all animals which approach it, with symptoms similar to those which animals suffer when placed under an exhausted receiver of an air-pump.

Others, though perfectly invisible, produce the same effects. Such are, says the learned translator of Lehman, those which issue from a cave in Hungary, situated near Ribard, at the foot of Crapack mountains. These vapors are so fatal that they kill birds, while in their flight they approach too near to the mouth of the cave.

Amongst the noxious mineral exhalations we may also place those which are found in the mines of Sal-gem in Poland. These frequently appear in form of light flocks, threads, and webs, like those of spiders. They are remarkable for their property of suddenly catching fire at the lamps of the miners with a terrible noise and explosion. They instantly kill those whom they touch. This explosion is a true subterranean thunder. Similar vapors are found in some mines of fossil-coal.

As arsenic is the greatest poison of all mineral substances, as it is volatile, and abounds in almost all mines, many authors have supposed that dampers contained something arsenical. But this opinion is so far from being proved, that strong reasons induce us to believe that they are of a different nature. We are certain, and I know it from my own experience, that a person may be a considerable time exposed to a large quantity of vapors of arsenic without suffering any of the symptoms occasioned by dampers, and even without being much incommoded.

Secondly, the effects produced by arsenic taken internally, even in a large quantity, although terrible, and always fatal, are not nearly so sudden as those occasioned by damps, which instantaneously kill. Thirdly, no observation or experience have ascertained the arsenical nature of any damps; and it is even demonstrable, that many of these noxious mineral vapors are nothing else than volatile sulphureous acid.

Lastly, all those which are not evidently volatile sulphureous acid appear to be pure, or almost pure phlogiston disengaged from bodies without burning. They occasion exactly the same accidents as exhalations of liver of sulphur, of burning coals, and of matters undergoing the putrid or spirituous fermentations. The great inflammability of these vapors, when they are confined, and condensed to a certain degree, such as those of coal-mines, is a demonstrative proof of this opinion.

By art we may perfectly imitate these vapors. We know that when acids dissolve imperfect metals, they take from them a considerable part of their inflammable principle. This principle is almost totally dissipated in vapors during these solutions; and if the operation be made in a close vessel, when this is uncorked, and a lighted candle brought near its mouth, the vapor contained instantly catches fire, and occasions an explosion so much more violent as the quantity of vapor was greater. This phenomenon may be chiefly observed in the solution of iron in vitriolic acid diluted with a certain quantity of water. If after this explosion the bottle be left open, supposing the solution of the metal to be continuing, and the flame of a candle applied to the mouth of the containing vessel; the phlogiston, which is continually disengaging and forming vapors, but freely and without condensation, will continue to burn in such a manner, that a light-bluish flame will be seen at the mouth of the vessel, such as the flame of phlogiston always is when this is not in an oily state.

Although these experiments are generally made by means of a solution of filings of iron in vitriolic acid, I doubt not that, by employing proper management, similar vapors might be produced from other imperfect metals, especially those which most easily part with their phlogiston when dissolved by acids, as tin, zinc, and regulus of antimony; and I doubt not that if these metallic vapors were collected in a sufficient quantity in a close place, where the air was not renewed, that they would produce the same fatal accidents as these called damps.

All these considerations induce us to believe, that most of these noxious subterranean vapors are nothing but phlogiston disengaged from certain substances, and circulating within the earth. It proceeds from bitumens and from sulphur, which undergo different alterations and decompositions.

Almost all chemists and metallurgists agree in believing, that mineral exhalations contribute to the production of metals. This opinion is so much more probable, that, as phlogiston is one of the principles of metals, (if it be true that these mineral exhalations are nothing else than phlogiston) and as this principle is then in state of vapor, and consequently much divided, perhaps reduced to its smallest integrant particles, it is then in its most favorable state for combination: it is therefore probable, that when these exhalations meet earths disposed to receive them, they combine more or less intimately with these earths, according



cording to their nature. Perhaps this is the chief operation of the grand mystery of metallisation. See METALS and PHLOGISTON. (m)

CCXX. DE CANTATION. By this word is meant the separating of a clear liquor from a sediment, by pouring it gently.

CCXXI. DE COCTION. This word is applied to signify either the action of boiling a substance in water, or the water itself in which the substance has been boiled.

Decoction is only applicable to matters containing some principles soluble in water; such, particularly, are vegetable and animal matters; and this operation is rather used for the purposes of medicine than of chemistry.

It is nevertheless very necessary to know well the nature and principles of substances subjected to decoction, that it may be properly managed, and that the principles with which the water becomes impregnated may be known.

These principles must evidently be such as are not sufficiently volatile to rise with the heat of boiling water, if the decoction shall be long continued.

Hence it follows, that plants, or other matters containing volatile principles, cannot be proper subjects of decoction, when these principles are required. In this case the matters may be infused with water in close vessels without heat, or with a heat less than that of boiling water.

(m) The damps or vapors mentioned in this article are of two kinds, *inflammable* and *uninflammable*. The inflammable kind is probably, as the author believes, similar to the vapors produced by the solutions of iron, zinc, tin, and perhaps of other metallic substances in vitriolic and marine acids. See AIR (FIXABLE). This vapor is chiefly found in coal mines, and sometimes in lead mines, as in those of Mendip hills. Like the inflammable vapor of metallic solutions, it is lighter than atmospherical air, and consequently floats chiefly near the roofs of mines: miners, therefore, when it is accidentally inflamed, or when they purposely set fire to it, to destroy it, lie flat on the ground, and thus escape burning. This inflammable vapor may perhaps be produced by the decomposition of pyritous matters, with which most mines, especially coal mines, abound. In this decomposition of pyrites exposed to air and moisture, the vitriolic acid of the sulphur attacks and dissolves the iron, while the inflammable principle of the sulphur is disengaged, and forms this vapor.

The *uninflammable vapors* of mines and subterranean places are much more noxious than the former. They seem to be similar to the uninflammable vapors produced by the combustion of inflammable bodies, as of charcoal, and by fermenting and effu-

vescing substances. See AIR (FIXABLE). Like these, they are noxious to animals, extinguish with flame, and are heavier than atmospherical air; for they are chiefly placed at the bottom of the pits in which they are found: accordingly, in the cavern near Pyrmont, mentioned in the text, a man may stand upright without any other inconvenience than an uncommon heat of his lower extremities, but he cannot without danger keep his head bent down. The symptoms attending persons exposed to such vapors shew sufficiently that they are not noxious merely by interception of common air, but by some quality which almost instantly affects and destroys the powers of animal life. Some persons digging in a cellar in Paris were found dead, stiff as statues, with open eyes, and standing in the posture of digging. At Chartres, in France, a person going down into a cellar into which a baker had been used to throw hot embers from his oven, was instantly killed; and when his body was opened, his lungs were found spotted with black marks; his intestines swollen, red and inflamed; and the muscles of his legs, thighs, and arms, seemed to be separated from each other and from the adjacent parts. See Bomare's *Dict. d'Histoire Naturelle*, at the word EXHALAISON.

But on the contrary, when it is not intended to preserve the volatile parts, or when the matters contain none that are volatile, then decoction may be employed. It even becomes necessary when the matters to be treated are solid, and of a compact and close texture; because then the water could not extract its principles without a boiling heat.

Most soft animal matters, as flesh, tendons, skins, may be boiled conveniently in water; because they contain no principle volatile with a boiling heat. Water extracts from them nothing but a gelatinous substance, and some oily parts which float on the surface of the water.

Decoction is the only method by which all the gelatinous substance of the solid parts of animals, as bones and horns, can be extracted.

All vegetable matters which are inodorous, and particularly those which are hard, as roots, barks, are generally boiled when an extraction of their principles by water is required.

However, many of these substances ought not to be boiled; those particularly, the principles of which, when extracted by water, suffer some change by a continued heat. Peruvian bark, for instance, which is inodorous, and contains nothing volatile, seems capable of being treated without any inconvenience by boiling; nevertheless, Mr. Beaumé observes, in his *Elements of Pharmacy*, that the infusion of this bark made without heat really contains more of its principles than the decoction. The cause of this is, that water extracts from bark not only the substances of which it is naturally a menstruum, such as the gummy and extractive matters, but also a considerable quantity of resinous substance, which keeps well dissolved in the water by means of the former matters, till it is exposed to heat, and then it immediately separates and precipitates.

Many other vegetable matters exhibit the same phenomenon; therefore a general rule may be established, that decoction ought not to be employed but when absolutely necessary, that is, when the same principles or the same quantities of these principles cannot be obtained by an infusion, and that without heat, if it can be so done, considering that the proximate principles of vegetables are generally so delicate, and so susceptible of change and decomposition, that frequently the most gentle heat changes much their nature and properties. See EXTRACTS.

**CCXXII. DECOMPOSITION of BODIES.** The chemical decomposition of bodies consists in the disunion and separation of their principles and constituent parts.

This decomposition ought necessarily to be distinguished from a mere mechanical division, as the following reflections will shew.

All bodies in general, or portions of any matter, may be considered as composed of parts separable from each other.

We cannot, for instance, conceive an atom of matter so small, but that this atom may be considered as divisible into parts still smaller; and this undoubtedly has given the idea of the infinite divisibility of matter, a subject which we do not mean to examine here, because it does not belong to chemistry; besides that, it is like all those in which the consideration of infinity is concerned, that is, an absurdity seems to be joined with evidence.

As chemistry is a science solely founded on experience, we shall confine ourselves to what experience teaches concerning the divisibility of bodies.

But

But we are certain that bodies may be very soon reduced to so small parts that we cannot further divide them, from the deficiency of our senses and of our instruments.

One thing is very remarkable in this division, called mechanical; because it is performed by cutting or bruising instruments; this is, that however small the parts be into which it reduces bodies, these parts are always entirely of the same nature as the body from which these parts were taken. These small parts of bodies are called their integrant parts. Thus, for example, the smallest atoms into which iron, salt, resin, or other substance, can be mechanically divided, have all the same properties, excepting quantity, which the mass had before the division.

Hence we ought to conclude, that this mechanical division cannot separate bodies but into homogeneous parts, or parts of the same nature: and if we had no other method of dividing bodies, the compounds would always remain such as nature offers to us, without causing any other change than a diminution of quantity.

The same thing would happen, if all natural bodies were equally simple, or equally compounded. But all chemical experiments shew, that in this respect there is a very great diversity.

Some bodies are so simple that no change can be produced upon them by any effort of art. These are called by chemists elements, or primitive principles. But these simpler bodies, the parts of which are evidently more small and fine than those of bodies less simple, become in the hands of chemists instruments capable of dividing these latter much further than can be done by mechanical instruments. These simple bodies are capable of dividing molecules, which would be still imperceptible by our senses, although they were much larger than they are when they have undergone this invisible division.

To illustrate this by an example. Let us suppose a metallic mass composed of mercury and gold, in such proportion that no mercury can be forced out from the mass by expression, which is a mechanical method. I say then, that the mechanical division which could be made of this compound, would only separate it into smaller and smaller molecules, each of which would be of the same nature as the original mass, that is to say, composed of an equal proportion of mercury and gold.

If indeed we had instruments and senses sufficiently fine, we might at length come to molecules, each of which would be composed of one atom of mercury and gold, which by one division more would be separated into two atoms, one of each of the two metals distinctly. Thus we might obtain the mercury and the gold separately, and consequently effect a decomposition of the compound substance subjected to this mechanical division: but the impossibility of such a division is sufficiently demonstrated.

Yet what mechanical instruments cannot do, fire, which is one of those simple bodies we have mentioned, is capable of performing. The primary parts of this element, much finer than those of gold or of mercury, become in the hands of chemists instruments inconceivably fine, which effect a separation of mercury from gold, consequently reduce to its elements or principles the compound

pound which has been subjected to their action, and thus analyse or chemically decompose it. See ANALYSIS.

CCXXIII. DECREPITATION. By decrepitation is meant the quick separation of the parts of a body, occasioned by a strong heat, and accompanied with noise and crackling. This effect is most frequently produced by water contained betwixt the parts of a decrepitating body, when these parts have a certain degree of adhesion together. This water being quickly reduced into vapors by the heat suddenly applied to it, rarefies and bursts with noise the parts which compress it.

The bodies most subject to decrepitation are certain salts, such as *common salt*, *nitriolated tartar*, *nitre of lead*, the decrepitation of all which proceeds from the water of their crystallization, *clays* which are not perfectly dry, and *flints*.

CCXXIV. DELFWARE. This is a kind of pottery of baked earth, covered with an enamel or white glazing, which gives it the appearance and neatness of porcelain.

Some kinds of this enamelled pottery differ much from others, either in their sustaining sudden heat without breaking, or in the beauty and regularity of their forms, of their enamel, and of the painting with which they are ornamented.

In general, the fine and beautiful enamelled potteries, which approach the nearest to porcelain in external appearance, are at the same time those which least resist a brisk fire. Again, those which sustain a sudden heat are coarse, and resemble common pottery.

The basis of this pottery is clay, which is to be mixed when too fat with such a quantity of sand, that the earth shall preserve enough of its ductility to be worked, moulded, and turned easily, and yet that its fatness shall be sufficiently taken from it, that it shall not crack or shrink too much in drying or in baking.

Vessels formed of this earth must be dried very gently to avoid cracking. They are then to be placed in a furnace to receive a slight baking, and which is only meant to give them a certain consistence or hardness. And, lastly, they are to be covered with an enamel or glazing, which is done by pouring upon the vessels thus prepared, the enamel which has been ground very fine and diluted with water.

As vessels on which the enamel is applied are but slightly baked, they readily imbibe the water in which the enamel is suspended, and a layer of this enamel adheres to their surface. These vessels may then be painted with colors composed of metallic calxes mixed and ground with a fusible glass. When they are become perfectly dry, they are to be placed in the furnace included in cases of baked earth, called *jeggars*, and exposed to a heat capable of fusing uniformly the enamel which covers them.

This heat given to fuse, the enamel being much stronger than that which was applied at first to give some consistence to the ware, is also the heat necessary to compleat the baking of it. The furnace and the colors used for painting this ware are the same as those employed for porcelain. See PORCELAIN.

The glazing, which is nothing but white enamel, ought to be so opake as not to shew the ware under it. Many receipts for making such enamels may be found in Neri's *Treatise on the Art of Making Glass*, with Kunkel's *Notes*, and in the *Encyclopedia*, both which books may be consulted on this subject. We shall

shall only observe in general, that all these enamels for delf-ware are composed of sand or flints, vitrifying salts, calx of lead, and calx of tin; and that the sand must be perfectly vitrified so as to form a glass considerably fusible. Somewhat less than an equal part of alkaline salt, or twice its weight of calx of lead, is requisite to effect such vitrification of sand. The calx of tin is not intended to be vitrified, but to give a white opaque color to the mass; and one part of it is to be added to three or four parts of all the other ingredients taken together.

From these general principles, various enamels may be made to suit the different kinds of earthen to which they are to be applied.

To make this enamel, lead and tin are calcined together with a strong fire, and the sand is also to be made into a fritt with the salt or ashes. The whole is then to be well mixed and ground together. This matter is then to be placed under the furnace, where it is melted and vitrified during the baking of the ware. Then it is to be ground in a mill, and applied as we have directed. See CLAY, POTTERY, PORCELAIN, and VITRIFICATION.

CCXXV. DELIQUESCENT. We understand by deliquescence the property which certain bodies have to attract moisture from the air, and of becoming thereby liquid.

This property is never found but in saline substances, or in matters containing them. It is caused by the great affinity which saline substances have with water. Hence, the more simple these substances are, the more also they are deliquescent. Acids, for instance, and certain alkalis, which are the most simple of saline substances, are also the most deliquescent. Mineral acids are so deliquescent that they strongly imbibe moisture from the air, although they are already mixed with a sufficient quantity of water to be fluid. For this purpose it is sufficient that they only be concentrated to a certain degree.

Many neutral salts are deliquescent, chiefly those whose bases are not saline substances. Their acids are but imperfectly saturated; and although they do not give the same marks of acidity as when quite disengaged, they may be considered as still possessing enough of their activity to exercise it on the moisture of the circumambient air. This proves, that the acids of neutral deliquescent salts are in an intermediate state betwixt that of an acid quite disengaged, and that of one perfectly saturated and combined.

All the phenomena which salts present relatively to their deliquescence, are so many proofs of what we have affirmed on this subject.

Salts formed by vitriolic acid with fixed or volatile alkalis, earths, or metallic substances, are not deliquescent; although this acid be the strongest of all, and which, when disengaged, most powerfully attracts moisture from the air. But its greater strength is the real cause of its forming so complete and intimate combinations with these several substances as to form neutral salts which are not deliquescent.

The nitrous and marine acids form with absorbent earths and certain metallic substances, particularly with iron and copper, deliquescent salts, from the weakness of the union which they contract with these matters. These acids form with silver, mercury, lead, and bismuth, salts which are not deliquescent, because they combine more intimately and completely with these latter metals.

Singular phenomena are presented by vegetable acids relatively to the deliquescence of the neutral salts formed by them. The acid of vinegar united with fixed vegetable alkali forms a very deliquescent salt, called *terra foliata tartari*. The same acid forms with copper a salt that is not deliquescent, as we see in the instance of *crystals of copper*. These effects are directly contrary to those produced by the nitrous and marine acids united with the same substances; for these acids form with fixed vegetable alkali salts which are not deliquescent, and with copper salts which are very deliquescent.

The acid of tartar, which when disengaged is in a concrete state, and far from being deliquescent, since it is scarcely soluble in water, forms with iron (another substance still less soluble) a very deliquescent soluble tartar, known by the name of *tartarised tincture of iron*.

Many researches and experiments remain yet to be made to explain entirely the causes of these singular effects. But probably the deliquescence or opposite quality of salts will be found to depend on the state of their acids, as we have already said.

The fixed vegetable alkali is deliquescent, the mineral is not. The cause of this undoubtedly is, that the saline principle of this latter is combined more intimately, or with a greater quantity of matter not saline, than that of the former, as the other properties of these two alkalis indicate. *See ALKALI*.

Fixed vegetable alkali treated with quicklime becomes more deliquescent. Volatile alkalis, which are naturally not deliquescent, become by treatment with quicklime deliquescent. We cannot explain these phenomena without supposing that quicklime takes from alkalis in general a portion of oily or other matter, which binds and saturates their saline principle, when in their natural state.

The dry extracts of almost all vegetable matters easily moisten in the air. But they certainly possess this property so much more evidently, as a greater quantity of earthy or resinous matter, which is always deposited during the evaporation, has been previously separated from their infusions and decoctions.

Before we finish this article we ought to observe, that some bodies which are not deliquescent attract moisture from the air, and even become liquid, that is, if they be saline or soluble in water. This happens when bodies are much colder than the air to which they are exposed. The reason of it is, that the moisture contained in the air being always in the state of insensible vapors, is condensed by the cold of the bodies it touches, and is collected in drops. This effect is very different from a true deliquescence, but it deserves to be taken notice of, to prevent mistakes in experiments.

Lastly, we must remark, that some bodies, after having been a long time exposed to the air, may remain apparently dry, although they really be in the disposition of deliquescent bodies, that is, attract much moisture from the ambient air. Such, for instance, is quicklime, which imbibes from the air its equal weight of moisture, and retains, notwithstanding, its dry and powdery appearance. This proceeds from the great quantity of earthy parts with which those parts of the quicklime are mixed, which may be considered as deliquescent, although, in fact, they do not resolve into a liquid.

**CCXXVI. DELIQUIMUM.** This term is frequently employed by chemists to characterize a body which is resolved into a liquid by exposure to air.

air. In this sense they say the deliquium of a salt, as of salt of tartar, for instance. This word is also frequently used instead of deliquescent. Thus we say, that a salt falls into a deliquium, to signify that it is deliquescent.

**CCXXVII. DEMI-METAL.** The same as SEMI-METAL; *which see.*

**CCXXVIII. DEPHLEGMATION.** Dephlegmation is an operation by which the superabundant water of a body is taken from it, and it is principally effected by evaporation or distillation. Dephlegmation is also called concentration, particularly when acids are the subject. *See* CONCENTRATION.

**CCXXIX. DETONATION.** By the word *detonation* chemists understand an explosion with noise made by the sudden inflammation of some combustible body. Such are the explosions of *gun-powder*, *fulminating gold*, and *fulminating powder*. As nitre is the cause of most explosions, the word *detonation* has been appropriated to the inflammation of the acid of this salt with bodies containing phlogiston, and it is frequently given to these inflammations of nitrous acid which are not accompanied with explosion. Thus nitre is said to detonate with sulphur, with coals, with metals, although, in the ordinary method of making these operations, that is, in open crucibles, and with small quantities of detonating substances, the nitre does not truly explode.

**CCXXX. DETONATION of NITRE.** The detonation of nitre is one of the most important phenomena of chemistry. It consists in the instantaneous inflammation and decomposition of the acid of nitre, when it immediately touches combustible bodies, the phlogiston of which is ignited, or when the acid is ignited.

By two methods then may nitre, or rather its acid, be inflamed. The first method is by applying it to a red-hot combustible body; and the second is by making the acid itself red-hot, and applying a combustible body to it in that state.

A very necessary remark is, that nitre cannot detonate without the concurrence of these circumstances now mentioned. Nitre may be made red-hot, or of any degree of heat, without shewing any sign of inflammation, provided it does not touch any inflammable matter.

On the other side, nitre may be heated, and a combustible body applied to it without any inflammation. For this purpose, the nitre need only be not sufficiently hot to kindle the inflammable bodies applied to it. Messrs. Macquer and Beaumé show, in their *Course of Chemistry*, an experiment which clearly proves this truth. Some nitre is put into a crucible, and there completely fused by a heat just sufficient for that purpose; when a black coal is thrown into this fused nitre, no inflammation arises, because the nitre may be melted with a degree of heat which is not sufficient to kindle combustible bodies; and this degree of heat is necessary for the success of the experiment.

But when nitre is red-hot, and a coal is applied to it, kindled, or not kindled, then it is inflamed with violence, and makes the coal burn rapidly. The same event happens when nitre is thrown upon burning coals. This inflammation lasts while these two substances touch, and any acid remains in the nitre. During this detonation a considerable smoke rises, but this smoke contains no acid, as the experiment of the effluvia of nitre made in close vessels sufficiently proves. *See* **Effluvia of Nitre.**

When all the nitrous acid is thus burnt, and no longer any inflammation is excited, although more coals are added, if we examine what remains in the crucible, we shall find that it is the fixed alkali which was the basis of the nitre. This alkali is called *fixed or alkalisied nitre*. See *these words*, and ALKALI (FIXED VEGETABLE).

The detonation may be rendered more easy and sudden by making the nitre touch the inflammable matter in a greater number of parts; so that when these two substances are divided into very minute parts, which are well mixed and interposed betwixt each other, the detonation is almost instantaneous, and is as strong as it can be made. When the substances are thus prepared, they may be at once inflamed by a small spark of ignited matter; because the ignition is very quickly and almost instantaneously communicated by small intervals. From the accurate mixture of the two detonating substances proceeds the great force and violence of *gun-powder*. See POWDER (GUN).

Hence we may learn to avoid the violence of detonations in chemical operations, by mixing very imperfectly the nitre with the combustible substances.

Let us now consider what passes in the detonation of nitre. Mr. Macquer, in his Elements of Chemistry, conjectures that the detonation of nitre, which is, properly speaking, the inflammation of the nitrous acid, cannot take place, unless a combination be previously formed betwixt this acid and the phlogiston of the combustible substance used for the detonation; that this combination is entirely similar to that of vitriolic acid with phlogiston when sulphur is formed; and that, in the present instance, a *nitrous sulphur* is produced; but that this sulphur is infinitely more combustible than the vitriolic sulphur, for a reason we shall soon see, and even so combustible, that it cannot exist an instant without being entirely burnt; hence it is inflamed with extreme rapidity and violence as soon as it is formed.

The most essential circumstances attending the detonation of nitre concur in rendering this opinion probable, that is, to establish the preliminary existence of this nitrous sulphur.

First, vitriolic sulphur cannot be formed by vitriolic acid engaged with a fixed alkali, unless this acid be deprived of all the water superabundant to its saline essence, and in a dry state, when it is applied to phlogiston.

In the second place, to effect this combination, a degree of heat equal to that of ignition must be applied.

Thirdly, as in sulphur not a particle of oil exists, but the vitriolic acid is united to pure phlogiston, as the illustrious Stahl has fully demonstrated; if, therefore, an inflammable matter, which is in an oily state, be used for the formation of sulphur, it must be first decomposed, and reduced to the state of coal, before the sulphur can be produced. See SULPHUR. But these are precisely the same conditions which are necessary for the detonation of nitre, for since the acid of nitre cannot detonate unless it be ignited, it must be evidently deprived of all the water superabundant to its saline essence.

In the second place, experience shows that nitre cannot detonate with any matter which is in an oily state; for if nitre be ignited in a crucible, and oil, resin, fat, or other inflammable matter of this kind be added to it, no detonation will happen while the inflammable matter remains in its oily state, or till it be burnt, decomposed, and reduced to a coal; then the detonation commences, and.



and is always proportionable to the quantity of coal produced by the inflammable matter.

Some substances, the phlogiston of which is certainly in an oily state, such as tartar, saw-dust of wood, and others of this kind, do indeed detonate with nitre almost as readily as powder of charcoal; but we may easily perceive that the cause of this is, that the oil of these substances, being divided by the interposition of a large quantity of inflammable matters, may be exceedingly soon reduced to the state of coal by the heat of ignition.

Several facts intimately connected with the detonation of nitre may be naturally deduced from this theory, and consequently become additional proofs of it.

Let nitrous acid, as much dephlegmated as possible, be poured upon black coals, as dry and hot as they can be made, under a red-heat, no detonation or inflammation will ensue. This is not surprising, since all the necessary conditions for the production of nitrous sulphur are wanting here, and since in similar circumstances sulphur could not be formed by vitriolic acid.

If an ardent coal be plunged into the strongest nitrous acid, a detonation begins at the surface of the coal, which very soon ceases; the coal is extinguished, becomes black, and is not affected by the acid. The short detonation upon the surface of the coal may be considered as accidental, and not belonging to the experiment; otherwise the detonation would continue while the acid lasted. This detonation can only be caused by a small quantity of nitre, formed instantaneously by the acid uniting with some small portion of alkaline salt contained in the surface of the coal, which happens to lie on its surface: therefore, when this small quantity of nitre is consumed, the coal is extinguished, and the detonation ceases; and all this ought to happen because the most dephlegmated nitrous acid contains always a considerable quantity of water superabundant to its saline essence, and as it is not in the present experiment retained or fixed by any basis, it dissipates in vapors before it can be totally dephlegmated by the heat of the ardent coal: hence in this experiment no nitrous sulphur can be formed; neither can vitriolic acid form vitriolic sulphur in similar circumstances, but only volatile sulphurous acid.

From these facts we may conclude, that nitrous acid, while free, that is, not engaged in any basis, cannot ever contract with phlogiston such an union, as that a sulphurous compound, or nitrous sulphur, shall be formed; not only because of the superabundant water it always contains, but also because, from its want of fixity, it cannot be deprived of this superabundant water in the very act of combination: we may therefore affirm as a general and established principle, that disengaged nitrous acid is not capable of detonation. If then this pure acid inflames oil mixed with it, this inflammation proceeds from a very different cause than the true detonation of nitre, as Mr. Macquer has shewn in his *Elements of Chemistry*; pure and disengaged nitrous acid being very different from each other, particularly with regard to detonation. *See INFLAMMATION OF OIL.*

What we have said on this subject clearly shews why combinations of nitrous acid with certain bases form nitres susceptible of a strong detonation, while others of the same acid with different bases detonate weakly or not at all; these differences depending on the greater or less adhesion of the nitrous acid with its basis. All those

nitrous

nitrous salts in which the acid is so firmly fixed and retained by its basis, that it may be entirely dephlegmated and ignited, are susceptible of a strong detonation; such are *ordinary nitre*, *cubic nitre*, *nitrous ammoniacal salt*, *nitres of silver*, *of mercury*, *of lead*, and *of bismuth*; of all which ordinary nitre detonates most violently, and is the only one of which good gun-powder can be made; because the fixed vegetable alkali, which is the basis of niter, has a stronger adhesion to nitrous acid than any other of the substances soluble by this acid.

On the contrary, all combinations in which nitrous acid is only weakly united, do not detonate, or very weakly. Such are *nitres with bases of calcareous earths*, *of copper*, *of iron*, *of tin*, *of regulus of antimony*; these being all nitrous salts in which the acid adheres weakly, as their deliquescent quality, and the facility with which fire detaches this acid from them, sufficiently shew.

We shall now examine what happens in the very act of the detonation of nitre, or rather in the deflagration of nitrous sulphur. We have seen that this sulphur is formed in the same circumstances as vitriolic sulphur; but if these two compounds resemble each other in the manner of their production, they differ entirely in the phenomena of their combustion.

Vitriolic sulphur burns very weakly, produces a flame which is very little luminous; requires for the continuance of its burning a constant supply of new air; and its acid undergoes no change by this combustion. Nitrous sulphur, on the contrary, appears incapable of existing an instant without burning. Its vivid, dazzling flame, accompanied with noise, resembles the flame of a fire strongly agitated by a blast of air; it needs not the contact of external air; it burns with the same violence and rapidity in close vessels; no obstacle is capable of containing it; and if it be confined, it bursts such a vessel as the sides of the confining vessels; lastly, after its combustion no trace is found of its acid.

What can be the cause of so considerable difference? and how are so singular phenomena produced? We cannot do better than adopt entirely the theory of Stahl. This great chemist has explained all these effects in a manner the most satisfactory, and the most conformable to the principles of rational chemistry.

Stahl considers nitrous acid as composed of a vitriolic principle, and of an earthy principle, as well as all other acids; but he also admits a third element to enter into this acid, by which it is characterized, and by which it differs from vitriolic acid. This third principle of nitrous acid is phlogiston; but this principle is so proportioned and combined with the other two, that nitrous acid is not inflammable while alone, even when it is ignited; but a new quantity of inflammable principle unites with nitrous acid, (which happens in the production of nitrous sulphur) then the proportion of this principle being increased, it accordingly assumes all the properties, and particularly the inflammability, which is essential to it. Hence nitrous acid cannot be combined with a body containing phlogiston, so disposed as to be capable of combining with it as nitrous acid; that is, a nitrous sulphur, without producing an inflammation. If then phlogiston united intimately with vitriolic acid forms a vitriolic sulphur, which is much less inflammable, this happens because phlogiston is not one of the principles of vitriolic acid, and does not enter into its combination, as it enters into that of nitrous acid.

From this cause also, namely the existence of phlogiston in nitrous acid, as a principle, Stahl deduces the destruction or total decomposition of this acid, when

when it is inflamed, and this he does upon good grounds; for then not only the phlogiston which is combined superabundantly with nitrous acid is inflamed, but also this superabundant phlogiston, finding itself mixed and confused with the phlogiston which is a principle of nitrous acid, takes this along with it in its inflammation, and the whole is entirely consumed.

This being established, we ought not to wonder that no nitrous acid is found after the detonation; for every compound body, from which one of its principles is taken, is thereby necessarily decomposed. If the inflammable principle of this acid could be consumed without destroying the connexion of the other principles, we should not indeed find after detonation any nitrous acid, because the phlogiston, its distinguishing principle, would have been taken from it; but as, according to Stahl, the union of the two principles, the watery and the earthy, is sufficient to constitute an acid, we should still find an acid substance of a different nature from nitrous acid, nearly in the same manner that we find pure vitriolic acid after the destruction of phlogiston which had constituted it volatile sulphureous acid has been taken from it: but things pass quite otherwise in the inflammation of nitrous acid; not a vestige remains of this, or of any other acid; nothing is found again but earth and water. This shews the connexion of the principles of nitrous acid to be such, that one of its constituent parts cannot be taken from it without an entire disjunction of the others; so that after its inflammation, it does not exist neither as nitrous, nor as any other acid.

We may easily perceive how much Stahl's facts, and the consequences resulting from them, give probability to the opinion of Stahl, who thinks that every acid, in general, results from an union of a watery with an earthy principle; and that the particular and specific properties of the several acids are caused by some other principle, which enters into their combination with these two essential constituent parts.

The explosion accompanying the detonation of nitre, and which is so much more violent as the matters have been more perfectly mixed, and more closely compacted, proceeds from a great and sudden dilatation of some very expansible body. Most natural philosophers have attributed it to air contained in nitre, and in matters with which the nitre desinates; because air included and rarefied is capable of producing, and does produce, very violent explosions: nevertheless, we must observe, that none of the explosions of air are equal in violence to those of gun-powder, or fulminating powder, and of fulminating gold, which are certainly effects of the inflammation of nitrous acid.

These considerations also incline us to adopt the opinion of Stahl on this phenomenon. The chemists think, that these explosions ought not to be attributed to the air, but to the water of the nitre, or rather of its acids; which is capable of producing much more violent explosions than those of air, when a strong heat, such as that of red heat, is suddenly applied to it, as happens in the detonation of nitre.

The same chemist goes farther. He advances, not without much probability, that water, the aggregation of which is entirely broken, acquires the properties of air. Upon this supposition we may well explain why nitre is capable of burning with combustible substances, without the access of air, and in close vessels. The reason of this is, that it contains in its own substance a matter which disengages itself from it while it burns, and which, if it is not air, has as

well

well, or better, the property of maintaining combustion. The name issuing from nitre when made to detonate so slowly that it can be observed, seems to prove what we have advanced on the subject; for it has, as we have said, all the appearance of the flame of a body excited strongly by a blast issuing from its own centre. (n)

Nitre detonates with sulphur, and with those metallic substances the phlogiston of which is so disposed that it can easily burn; such are iron, tin, zinc, and others of this nature. This detonation has nothing peculiar: it must happen not only from the combustibility of the phlogiston of these substances, but also because this phlogiston is not in the state of oil. What we have said concerning the detonation of nitre by coals, is applicable to those which are now treated. However, attention must be given to the other principles of these substances, and to the greater or less quantity, and degrees of combustibility of their phlogiston.

CCXXXI. D E W. Formerly this name was given to the phlegm that rose first in the distillation of several substances. Thus the *dew of vitriol*, the *dew of honey*, were watery liquors which rose first when these substances were distilled.

CCXXXII. D I A M O N D. Diamonds are stones of the vitrifiable kind, which are found naturally crystallized, nearly as rock-crystal is, in form of six-sided prisms, each extremity of which is terminated by a pyramid also of six sides. Some diamonds, however, are differently crystallized.

Diamonds are the most beautiful and the dearest of all precious stones. They are of different colors, particularly yellow; but the greatest part of them are white, and amongst these, the whitest and most transparent are of highest value. No stone is harder than the diamond; it is also very refractory, and even apyrous; it has all the properties of vitrifiable stones, with this difference, that it requires more fire, and a larger quantity of flux to produce its vitrification than any other of the substances of the same kind. See STONES (VITRIFIABLE). (a)

(n) The explosion of nitre deflagrated with inflammable substances is caused by an elastic fluid, which is produced from the nitre and these substances by deflagration. This fluid is not the water of the nitre rarefied and converted into air; for the water of the nitre is only rarefied by the heat of the deflagration, and is afterwards by cold condensed, forming the water called *clyssus* of nitre. See *Clyssus of Nitre*. But the elastic fluid produced by deflagration is permanent, and not condensable into a liquid. Mr. Robins found, by accurate experiments, that the fluid produced by firing gun-powder, when confined within a space equal to that of the gun-powder which was fired, and reduced to the heat of the atmosphere, was capable of sustaining a pressure equal to 244 times the pressure of the atmosphere, and that the elastic force of the fluid was in-

creased probably about four times by the heat produced by the firing of the powder; and consequently that it is thereby rendered capable, at the instant of explosion, of sustaining a pressure nearly equal to a thousand times the pressure of the atmosphere. See *Robins's Principles of Gunnery*.

(a) Diamonds are the most hard, heavy, transparent, and brilliant of all stones. They are either hexagonal prisms terminated by eight-sided points or pyramids, or they are flat, or cubical, or rounded. Whether this difference of form be original, or adventitious, has not been determined. The first kind are the best and hardest, and may therefore have preserved their original form against accidents better than the others, especially than those which are rounded, which are said to be the least hard, and consequently most liable to have their forms altered by attrition.

CCXXXIII. DIAPHORETIC ANTIMONY. This is a white calx of antimony, made by calcining antimony with thrice its quantity of nitre. See ANTIMONY.

CCXXXIV. DIGESTION. Digestion is an operation which consists in exposing bodies to a gentle heat, in proper vessels, and during a certain time.

This operation is very useful to favor the action of certain substances upon each other; as, for example, of well calcined, dry fixed alkali upon rectified spirit of wine. When these two substances are digested together in a matraass, with a gentle sand-bath heat, the spirit of wine acquires a yellow-reddish color, and an alkaline quality. It is then called *alkaline tincture*, or *tincture of salt of tartar*. See TINCTURE of SALT of TARTAR. The spirit would not so well acquire these qualities by a stronger and shorter heat.

attrition. Diamonds are said to consist of laminae or plates, and probably they have some uniform texture; because lapidaries find that they may be polished much more easily in one than in any other direction. This stone becomes luminous in the dark by exposure during a certain time to the rays of the sun; by heating it in a crucible; by plunging it in boiling water; or by rubbing it with a piece of glass. By friction it acquires an electrical property, by which it attracts the substance used for foils, called black mastic, and other light matters. The author of the Dictionary says, that diamonds are refractory in the fire, and even aspyrous. Nevertheless, experiments have been made, which prove that diamonds are capable of being dissipated not only by the collected heat of the sun, but also by the heat of a furnace. A diamond, by exposure to a concave speculum, the diameter of which was forty inches, was reduced to an eighth part of its weight. See *Phil. Trans.* No. 386. In the *Giornali di Letterati d'Italia*, Tom. viii. Art. 9. we may read a relation of experiments made on precious stones, by order of the Grand Duke of Tuscany, with a burning lens, the diameter of which was two thirds of a Florentine ell, near the focus of which was placed another smaller lens. By these experiments we find that diamonds were more altered by solar heat than most of the other precious stones, although not the least appearance of a commencing fusion was observable. A diamond weighing thirty grains, thus exposed during thirty seconds, lost its color, lustre, and transparency, and became of an opaque white. In five minutes,

bubbles appeared on its surface; soon afterwards it burst into pieces, which were dissipated; and the small fragment which remained was capable of being crushed into fine powder by the pressure of the blade of a knife. Neither the addition of glass, flint, sulphur, metals, or salt of tartar prevented this dissipation of diamonds, or occasioned any degree of fusion. By this heat, rubies were softened, and lost some of their color, but preserved their form and weight. By addition of a third lens, a further degree of fusion was given to rubies. Even then rubies could not be made to unite with glass. By having been exposed to this heat, the surface of the rubies which had suffered fusion, lost much of their original hardness, and were nearly as soft as crystal. But their internal parts, which had not been fused, retained their hardness. Emeralds by this heat were rendered white, or of various colors, and soon afterwards were fused. They were found to have lost part of their weight, and to be rendered less hard and brittle.

Experiments were also made by order of the Emperor Francis I. on precious stones, from which we find, that diamonds were entirely dissipated by having been exposed in crucibles to a violent fire of a furnace during twenty-four hours; while rubies by the same heat were not altered in weight, color, or polish. By exposing diamonds during two hours only at a time, the alterations produced on them by fire were observed. First, they lost their polish, then they were split into thin plates, and, lastly, totally dissipated. By the same fire, emeralds were fused. See *Magasin de Hambourg*, tom. xviii.



Digestion is also used to soften and open certain bodies designed to undergo further operations, or to excite in them a certain degree of fermentation.

CCXXXV. DISTILLATION. Distillation is an operation by which the fluid and volatile principles of bodies may be separated and collected with a convenient degree of heat.

If compounds containing volatile and fixed principles be exposed to fire, the former being rarefied by heat will endeavor to separate themselves from the latter; and if the effort which they make for this purpose be superior to the cohesion which they have with the fixed principles, a separation will happen, and they will be dissipated in state of vapor.

The different fixity and volatility, which the several principles of almost every compound body have, furnishes a very extensive method of separating and obtaining their principles. This chemists effect by distillation.

Distillation requires an apparatus of vessels suited to the nature of the substances to be treated, and of the principles to be obtained.

If the substance to be distilled be very compound, very susceptible of alteration by heat, and containing very volatile principles, such as most odoriferous plants, spirituous liquors, and others of this nature, a vessel must be used called an *alembic*, which must also be provided with a water-bath. See ALEMBIC.

As in the distillation made with an alembic the vapors rise vertically, and are condensed in the upper part of the vessel called its *capital* or *head*, this method of distillation has been called *per ascensum*. By this method may be distilled all matters volatile enough to rise with a degree of heat not exceeding that of boiling water: such are the *spiritus rectior of plants*, *ardent spirits*, and all *essential oils*.

When compound bodies are to be distilled, the most volatile parts of which require a heat superior to that of boiling water, *retorts* must be employed; because these vessels may be conveniently placed either in a sand-bath or in a naked fire, and may be so disposed in a reverberatory furnace, that the matter which it contains shall be equally heated on all sides.

The shape of a retort is such, that principles reduced to the state of vapor cannot issue but laterally through the neck of the vessel, which is accordingly placed on one of its sides. This distillation has thence been called *per latus*. See RETORT.

This second method of distilling is very useful, and may be applied to obtain essential oils, heavy acids, especially mineral acids, and sometimes even very volatile substances; as for example, the volatile alkali from sal ammoniac, or from animal matters which have not undergone putrefaction.

A third kind of distillation is called *per descensum*; because it consists in applying the heat above the bodies whence the volatile parts are to be extricated; and by this method these volatile parts are obliged to descend into a vessel prepared for their reception. But this method of distillation has many faults, is absolutely unnecessary, and is entirely neglected.

We may easily conceive what passes in distillation. Volatile substances are rendered by a suitable heat specifically lighter, are reduced to the state of vapor, and would be dissipated, if they were not retained, and obliged to pass into colder

colder places, where they are condensed and become liquors, if such be their nature; or else they collect in small solid particles called *flowers*, and in this case the operation changes its name, and is called *sublimation*. See *SUBLIMATION*.

As distillation is always performed in close vessels, the matters which rise are excluded from the access of air, which accelerates the ascent of volatile bodies. See *AIR*.

Hence distillations and sublimations, which are, properly speaking, only evaporations in close vessels, are more disadvantageous than evaporations in open air. This is an inconvenience in all cases where distillation may be carried on very fast without any accident. Such, for instance, is the distillation of water alone. This inconvenience may be in a great measure remedied by introducing into the cucurbit a current of air by means of a ventilator, according to a method proposed by an English chemist to accelerate the distillation of sea-water, with a design to obtain by that means fresh water from it.

But in distillations of almost all other substances, this slowness occasioned by want of air is rather useful than disadvantageous; because the more slowly a volatile substance is separated from a fixed substance, the more perfect is the separation. For this reason, when a distillation is required to be performed according to the rules of the art, it must be so conducted that no more heat shall be applied to raise the volatile body than is necessary. This management is particularly necessary when there is not a great difference betwixt the volatility of the principles of the body distilled. We have an evident example of this in all concrete oily matters. When we intend to separate the acid and the oil of which these matters consist, as these two principles have nearly the same volatility, they rise together, and are not disunited; so that the compound body passes in distillation without suffering any decomposition. See *BURRER*. Notwithstanding the most careful management of most distillations, the volatile principles are seldom obtained perfectly free from the other principles of the compound; and therefore, to be purified, must be submitted to new distillations, called *refinements*.

We may then establish, as general and essential rules of distillation, that no greater heat ought to be applied than is just necessary to raise the substances to be distilled; and that the slowness of the operation is no less advantageous than the hurrying of it too much is prejudicial.

These rules ought also to be observed for some other very strong reasons. Such is the prevention of the breaking of vessels, which frequently happens in those of glass or of earthen ware when they are too suddenly or too strongly heated, and most certainly happens when the vapors rise more quickly than they can be condensed.

These accidents are chiefly occasioned by vapors which are very elastic and not easily condensable. Some vapors, as these of the smoking nitrous and marine acids, have these qualities so strongly, that much of them is lost, by the necessity of giving frequently a vent to them, by unstopping a small hole made in the balloon employed as a receiver in such distillations, and which might be conveniently made in all receivers.

\* See *PLATES*; where the vessels used in distillations are represented.

## CCXXXVI. DITTANY of CRETE. (p)

CCXXXVII. DIVISION. By *division* we ought to understand that separation which is occasioned in the parts of a body by help of mechanical instruments.

The mechanical division of bodies does indeed separate them into smaller, homogeneous, similar parts; but this separation cannot extend to the primary integrant molecules of any body, and consequently is incapable of breaking what is properly called their aggregation: also, no union is formed betwixt the divided and dividing bodies, in which respect division essentially differs from *solution*.

Division is not properly a chemical operation. It is only employed preparatorily to facilitate other operations, and particularly solution. For this purpose it is very useful, as it encreases the quantity of surface, and consequently the points of contact of any body.

Different methods are used to divide bodies according to their nature. Those which are tenacious and elastic, as horns and gums, require to be cut, rasped, or filed. Metals, because of their ductility, require the same treatment: but as they also are fusible, they may be quickly and conveniently reduced into grains small enough for most operations, by pouring them, when melted, into water.

All brittle bodies may be reduced conveniently into fine parts by being bruised in a mortar with a pestle.

Very hard bodies, such as glass, crystals, stones, particularly those of the vitriifiable kind, before they are pounded, ought to be plunged when red-hot into water, by which they are split and cracked, and rendered more easily pulverable.

Bodies of this kind may also be bruised or ground by means of a hard and flat stone, upon which the matter is to be put, and bruised by another hard stone, so small as to be held and moved upon the larger stone with the hand. The larger stone is called a *porphyry*, from its being generally of that kind of stone; and the operation is called *porphyrisation*. Instead of porphyrisation, a mill may be used, composed of a hard gr. millstone, moving round upon another stone of the same kind, which must be fixed: in the upper stone is a groove, or channel, through which the matter to be ground passes. By this method a substance may be more quickly reduced to a fine powder than by porphyrisation. But these mills can be only employed for considerable quantities of matter, as for manufacture of pottery and porcelain.

These methods of mechanically dividing bodies are attended with some practical inconveniences; the most considerable of which is, that some parts of the dividing instruments are always struck off, and mixed with the matter to be di-

(p) DITTANY of CRETE. Sixteen ounces of the leaves of this plant yield about half a dram of a strong, aromatic, essential oil, which coagulates by cold, resembling camphor. From an ounce of this plant Neuman obtained with water two drams and a scruple of extract; and from the same quantity, with spirit of wine, he obtained a dram and

a half of resinous extract. He observes, that the green color of the leaves resides in the resin, and is extractable by spirit, especially after water has previously extracted the gummy part, some of which being also so soluble by spirit along with the resin, alter the color of the spirituous tincture.



vided. This may greatly affect the operations. For instance, instruments of iron and copper furnish coloring metallic parts, and the latter metal is hurtful to health. Porphyry is colored by a reddish-brown matter, which injures the color of crystal-glasses, enamels, and porcelain, made with matters ground upon this stone. These matters, therefore, must be cleansed after their porphyrisation, or else no instruments ought to be employed capable of injuring the intended operations. Thus, for the preparation of all medicines to be taken internally, no copper instruments, as mortars, pestles, ought to be used; those made of iron are preferable; and, instead of porphyries, mortars, grinding-stones, and mill-stones, made of hard and white stones, ought to be employed for substances which are to enter into the composition of enamels, crystal-glass, and porcelain, the whiteness of which is a most necessary quality.

**CCXXXVIII. DO CIMASTIC ART.** This name is given to the art of assaying, by operations in small, the nature and quantity of metallic or other matters, which may be obtained from mineral or other compound bodies. The most important operations of the docimastic art are found under the words, *REFINING, ORES, ESSAYS of ORES.*

**CCXXXIX. DOME.** The upper piece of furnaces, and particularly of portable furnaces, is called the *dome*. It has the form of a hollow semisphere or small dome. Its use is to form a space in the upper part of the furnace, the air of which is continually expelled by the fire; hence the current of air is considerably encreased, which is obliged to enter by the ash-hole, to pass through the fire, to supply the place of the air driven from the dome. The form of this piece renders it proper to reflect or reverberate a part of the flame upon the matters which are in the furnace, which has occasioned this kind of furnace to be called a *reverberatory furnace*. See *FURNACE*.

**CCXL. DORONICUM.** (*q*)

**CCXLI. DRAGON'S BLOOD.** (*r*)

**CCXLII. DUCTILITY.** Ductility is a property possessed by certain solid bodies, which consists in their yielding to percussion, pressure, and in receiving different forms, without breaking.

This property is nothing else than a continued adhesion of the integrant parts of those bodies which have this property, although these parts change place respectively to each other. A body, therefore, cannot be ductile, excepting its integrant parts be so disposed, that, while some of its contiguous parts are forced to separate, others apply themselves, so that the whole shall be still one continued substance.

(*q*) **DORONICUM.** From two ounces of the dry root were obtained by water fourteen drams of extract; and from the same quantity, with spirit, four drams and a half. This root is supposed by some to be poisonous, especially when fresh. *Neuman*.

(*r*) **DRAGON'S BLOOD** is a red-colored, inodorous, and insipid resin, unsoluble in water, soluble in spirit of wine and in oils, to both which liquors it communicates a red color. By fire it is fusible, inflammable, and

it emits an acid vapor like that of benzoin. A solution of dragon's blood in spirit of wine is used for staining marble, to which it gives a red tinge, which penetrates more or less deeply according to the heat of the marble during application. But as it spreads at the same time that it sinks deep; for fine designs, the marble should be cold. Mr. Du Fay says, that by adding pitch to this solution, the color may be rendered deeper.

The figure of the integrant parts of ductile bodies contributes also probably to their ductility : but as we have not any certain knowledge of the form of the integrant parts of any body, we cannot explain ductility more precisely and particularly.

Some bodies are ductile both when they are hot and when they are cold, and in all circumstances. Such are metals, and particularly gold and silver. Other bodies are ductile only when they have a certain degree of heat, such as wax, and substances of the same kind, and glass (*s*). The degrees of heat requisite to render these bodies ductile vary according to their different natures. In general, the heat must be such as to be in a middle state betwixt solidity and perfect fusion or fluidity. As wax, for instance, is fusible with a very small heat, it may be rendered ductile by a still smaller heat; and glass, which requires a most violent heat to be perfectly fused, cannot acquire its greatest ductility without being made red-hot and almost ready to fuse. Lastly, some bodies are rendered ductile by the interposition of the parts of a fluid. Such are certain earths, and particularly clays. When these earths have absorbed a sufficient quantity of water to bring them into a middle state betwixt liquidity and solidity, that is, to the consistence of a considerably firm paste, they have then acquired their greatest ductility. Water has precisely the same effect upon them in this respect as fire has upon the other bodies mentioned.

**CCXLIII. DULCIFICATION.** When caustic and corrosive bodies are rendered milder by being combined with another substance, they are said to be *dulcified*. This term is most commonly applied to the effect produced upon mineral acids by their union with spirit of wine. *See SPIRITS of NITRE, of SALT, and of VITRIOL (DULCIFIED).*

**CCXLIV. DYING.** The art of dying consists in extracting from various substances coloring particles, and applying them to stuffs or other matters intended to be dyed, so that they shall adhere as firmly and durably as possible. (*s*)

(*s*) Lastly, other bodies, as some kinds of iron, namely, those called by workmen *red-short*, brass, and some other metallic alloys, are ductile only when cold, and are brittle when hot. Concerning the ductility of metals, *see METALS*.

(*t*) **DYING.** Notwithstanding the labors of Messrs. Hellot, Astruc, Du Fay, Jussieu, and of some other authors, by which many processes for dying are ascertained; and notwithstanding the attempts of Mr. Hellot to explain these processes, yet the theory of dying is far from being known or established. We do not sufficiently understand the nature of the colorific particles of dying substances; nor the action of the salts and other matters used in most of the processes for durable dyes; nor the causes of the differences of the several stuffs made of wool, silk, cotton, or thread, with regard to their aptitude to re-

ceive certain dyes. Many experiments are required to elucidate these subjects.

Before we mention Mr. Hellot's Theory of Dying, we must observe, that dyers enumerate five colors which they call primary, from the mixtures of which the other colors are produced. These are blue, red, yellow, nut-color, and black. *Good dyes* are those which can resist the action of water, air, and of certain saline and saponaceous liquors which are used as proofs of the durability of colors. *False dyes* are those which cannot resist these proofs. We may easily conceive the action of false dyes; that a colored decoction should color any stuff dipped into it by the adhesion of part of it to the stuff; and that when the stuff has become dry by the evaporation of the water of the decoction, it may again be deprived by washing with water of the coloring substance; which being sojuble,

Although the principles of all the mechanical arts have a singular dependance on chemistry, as we have endeavoured to shew in many parts of this work, few of them are so intimately related to this science as the art of dying, all the operations of which are so many chemical operations. These operations must be described at full length to shew all their relations to chemistry; but these de-

soluble, as it was originally, in water,\* may easily be washed out of the dyed stuff: but the action of those dyes which, although once dissolved or suspended in water, cannot again, after they are applied to stuffs, be washed out, is not so easily understood. We shall here treat only of this latter sort, or good and durable dyes. Dyes of different colors require different treatment. Stuffs to be dyed of a *red* or *yellow* color must be boiled in water with alum and tartar before they are dipped into the dying decoctions: the red coloring materials are *kermes*, *cochineal*, *gum-lac*, and *madder*; the yellow materials are *luteola*, or *dyers weed*, and other *yellow flowers*. The stuffs for *blue* dyes require no previous preparation. These blue dyes are made of *indigo*, or the blue secula obtained from *woad* (*the Indigo and Woad*), dissolved in a lixivium of fixed alkali, or in urine, with or without the addition of some green vitriol. The stuffs intended to receive a *root color* require no previous preparation but to be soaked in warm water. These dyes are chiefly decoctions of *walnut shells*, *walnut-roots*, *alder-bark*, *sumach*, and *jaundisers*. To these no saline or other matter is added. The *black* dyes, which are *inks*, or decoctions of *galls*, mixed with *green vitriol*, require no previous preparation of the stuff.

Mr. Hellot's Theory of Dying is, that the coloring particles are fixed into the pores of stuffs chiefly by means of a vitriolated tartar, which he believes to exist in each process, to be produced by the acid of alum and alkaline basis of tartar in the process for red and yellow dyes, to exist originally in the pot-ash employed in the blue dye, and in the nuts and roots employed in the root-colored dye. He supposes that the pores of the stuff are cleansed and enlarged by the preparatory salts, and by the boiling water, so as to receive the coloring particles, which particles are afterwards detained by the contraction of the pores occasioned by cold; and further, that these pores are lined with a saline crust of vitriolated tartar, or of tartar;

which salts being difficultly soluble in water, retain firmly the coloring particles. But this theory cannot be admitted, when we consider, that vitriolated tartar does not exist in any of the materials used in some of the processes for dying, as in the root-color materials, from which no vitriolated tartar can be obtained, unless accidentally, till they have been by burning reduced to ashes, and even then the quantity is exceedingly small; that although common pot-ash generally contains some vitriolated tartar, yet Mr. Hellot has not shewn that pure fixed alkali is incapable of producing the same effect; and lastly, that vitriolated tartar and tartar, although they require much water to be dissolved, are yet soluble by water; and therefore if the coloring particles were fixed chiefly by means of these salts, they might be washed out by a large quantity of water; which we find to be contrary to experience.

We shall find it more difficult to substitute a true theory, than to refute that of Mr. Hellot. Many experiments ought to be previously made. Nevertheless we shall observe, that the colorific particles used in dying seem to be unsoluble in water, in spirit of wine, and even in alkaline lixiviums; that their diffusion through these liquids is caused merely by their adhesion to certain gummy and resinous particles; and that they may be disengaged from those gummy and resinous matters, by applying a piece of stuff, to which they have a greater adhesive power, which seems to be the case of the root-colored and blue dyes; or by applying another substance, to which they have a greater power of adhesion, such as the earth of alum, in those dyes where that salt is used together with some substance, as fixed or volatile alkali, capable of decomposing alum; or as the ferruginous earth of the green vitriol in black dyes, to which the colorific particles of the galls adhere; which earths are capable of applying themselves, and of adhering to the stuffs. The separation of the coloring particles from the gummy and resinous matters is probably facilitated by the addition of acid and

tails' would lead us too far from our object. We must confine ourselves to shew the most general principles of dying. These have been already explained in a preliminary discourse to the *Art of Dying Silk*, which is one of the dissertations upon the arts published by the Royal Academy of Sciences. We shall here only make an extract of what is said there, to oblige those readers who have not that collection.

Most vegetable and many animal substances contain coloring principles which may be extracted and applied to other bodies: but these coloring principles are not always nearly of the same nature, and in the same state, and these differences require that different methods should be employed for the extraction and application of them.

Some of these coloring particles reside partly in a saponaceous extractive substance, and partly in an earthy and resinous matter. When substances, the colorific particles of which are in this state, are boiled in water, they impregnate the water with their color; because a part of the resinous earthy portion is mixed and diffused in the water by means of the saponaceous extractive prin-

and neutral salts, which may coagulate in some measure the vegetable matters, and leave the colorific particles disengaged; so that they may apply themselves to the stuff, or to the above-mentioned earths. These salts are also useful by heightening certain colors; all acid salts and alum having the property of heightening the red colors of vegetables. The metallic salt used in the scarlet dye (which consists of a decoction of cochineal, to which a solution of tin in aqua regia, and some tartar are added) has also the effect of changing the crimson color of cochineal to a vivid scarlet; and probably has also the other effects of alum, of affording an earth, namely that of tin, to which the coloring particles may adhere, and of coagulating the vegetable matters, so that they shall leave the coloring particles detached and suspended in the water. The chief difference then betwixt the false and true dyes is, that the coloring particles in the former dyes are applied to stuffs, together with some gummy or resinous matter to which they adhere, and are therefore liable to be washed out along with these matters by any liquid capable of dissolving gums or resin: while the coloring particles of the true dyes are applied to stuffs, either alone, or adhering to some fine earth, as the earth of alum or of tin; and as both the coloring and the earthy particles are unsoluble in any liquids, to which they are most apt to be exposed, as water, soap-suds, &c. they are capable of resisting the action of these liquids, and are therefore durable. Some dyes are

also called *false*, because their colors are depraved by exposure to the sun and to the air. These effects cannot, I fear, be explained without a further knowledge of colors, and of the action of light and air upon colors, than has hitherto been communicated. We here treat not of the causes or changes of colors, but of the application and adhesion of coloring particles. To confirm our conjectures on this subject, we may observe, that when the coloring particles of vegetables and animals are diffused in an alkaline lixivium, by means of gummy, resinous, or oily matters to which they adhere, they may be separated from these adhesive matters by adding alum, the acid of which unites with the alkali of the lixivium; while the coloring particles apply themselves to the basis or earth of the alum, now disengaged, with which they form what are called by painters *lakes*, the coloring matter of which is not now soluble in water or in spirit of wine; although these liquids are capable of extracting that coloring matter from the vegetable and animal substances which contain it, by the intervention, as we suppose, of some gummy or resinous matters.

For further particulars concerning dying, and the chemical history of dying substances, see BLACK, BLUE, CRIMSON, &c. and COCHINEAL, INDIGO, FLOWERS, FRUIT, LEAVES, &c. The details of the particular processes in this art are described fully by Mr. Hellot, in his Treatises on the *Art of Dying*.

ciple. If a stuff be plunged in a decoction of such substances, the coloring particles are thereby made to touch and apply themselves to it, and even to adhere firmly; because the resinous earthy coloring principle, when once united to the stuff, and separated from the extractive principle, is no longer soluble either by water, soap, salts, or other active matters. Several substances are known, the coloring principles of which are in this state. Of these the chief are the *green shells of walnuts*, the *root of the walnut-tree*, *sumach*, *saunders*, *bark of alder*, and the shell-fish called *murex*, supposed to be the purple dye of the ancients. Excepting this latter substance, which gives a fine red, all the rest give a dun color, called a *root-color*, but which is valuable notwithstanding its little lustre; because it is very useful as a ground upon which other brighter colors may be applied. From the nature of these coloring ingredients we may perceive that no preparation is necessary for the colors, or for the matters to be dyed. They furnish the simplest and most practicable kind of dying; for all the operation consists in boiling the dying materials in water, and in dipping the stuff to be dyed in this decoction.

The coloring principle of another kind of substance is contained in a matter altogether resinous, which is so disposed that it cannot be rendered miscible with water by means of the saponaceous extractive principle of the same substance. The principal ingredients of this kind are *indigo*, which furnishes the blue dye, and the flowers of *cartamus*, or *bastard Saffron*, from which a very beautiful red is procured. Pure water cannot extract the colors from these matters. The blue resinous part of indigo is also of the nature of those which spirit of wine cannot dissolve: but as fixed alkaline salts are capable of acting upon all resinous matters, they are used successfully to extract the coloring parts of these ingredients, and to render them fit for dying.

The coloring principles of almost all the other vegetable and animal matters which furnish colors for dying, and which are very numerous, are of a purely extractive saponaceous nature, and may consequently be easily extracted by water alone; but as they are soluble in water, they might easily be washed away from the stuffs to which they have been applied, if these stuffs had not previously been impregnated with some matter capable of producing some change or decomposition on the coloring part.

A method has been found of fixing colors upon stuffs by different salts, with which the stuffs are impregnated before they are dyed. The extractive coloring particles are so changed by these salts, that they lose their property of being soluble in water, and are even rendered capable of resisting the action of soap, and other substances which are apt to destroy most colors, and are therefore used to prove the durability of these.

Of all the salts which may be employed for this purpose, *alum* is found to be the fittest: it is therefore generally employed for all extractive tinctures, which are very numerous, the principal of which are *luteoli*, or *dyer's-weed*, and all the herbs which give a yellow color, *madder*, *vegetable kermes*, *cochenil*, *brass-weed*, *log-wood*, and other woods and roots used in dying. *Alum* is not the only salt which has this effect. All neutral salts with metallic bases are capable of fixing the extractive colors: but some of these are very dear, and others change and spoil the colors; so that *alum* is solely employed for this purpose.

All these dyes cannot be equally well fixed by alum, or by the other salts above-mentioned. Some of them are only so much fixed by alum as to resist the action of water, but not of the other substances used to prove the fixity of colors, nor even of the air, during a long time. This latter kind of dyes are called *false* or *small tints*, to distinguish them from the more fixed dyes, called *great* or *good tints*.

These differences must proceed from the particular nature of each of the coloring materials : but very accurate analyses of these materials, and a great number of new researches must be made, before this obscure subject can be explained. It will even appear still more obscure, when we consider that the different nature of the substances to which the dye is applied, surprizingly affects the beauty and fixity of colors. For instance, the red color of madder, which is sufficiently beautiful and fixed upon wool and cotton, gives but a false tint upon thread ; also cocheneil, which gives a vivid and bright flame-colored red to wool, and even to most animal matters, does not adhere to silk, cotton, or thread. In the particular details of the processes for dying the different kinds of matters many other singular differences may be found, which require particular attentions to be explained. The most general inference from these particular details is, that wool and all animal matters are the most easily dyed ; next to them, silk and other substances, which seem to be intermediate betwixt the animal and the vegetable nature ; and last of all, thread, and vegetable matters.

The few facts and general principles we have advanced on the art of dying are sufficient to shew its connexion with chemistry, and how much it may be improved by this science.

## E

CCXLV. **E**ARTHS. Earth is one of the four simple substances called elements, or primitive principles; because they are indeed the most simple of all those which enter into the combination of compound bodies. We cannot doubt, in particular, that the greatest part of the compounds which we can analyse contain earth as one of their principles; for after art has exhausted all its efforts to decompose them, a fixed and solid matter always remains, upon which no change can be produced; and this is what is generally called earth. It has the solidity, weight, fixity, and other principal properties of the mass of solid matter which forms the globe we inhabit, called also *the earth*.

These general considerations are sufficient to convince us, that in nature a substance exists whose properties are different from those of fire, air, water; and which is, like these other substances, one of the elements of compound bodies. But a vague assertion like this does not satisfy chemists. Besides the ascertaining of the existence of the different substances submitted to their examination, they require to know the properties of these substances in their greatest degree of purity and simplicity: but they have found much difficulty and uncertainty in investigating the essential properties of the purest and simplest terrestrial element.

Earth is not found so pure as the other elements, fire, air, and water, which, though not entirely free from mixture, are however so pure, that we may certainly and easily discover their fundamental properties. These properties of each of these pure elements are so well ascertained, and so evident, that nobody has yet attempted to distinguish different kinds of fire, air, or water, notwithstanding the differences which may arise from the heterogeneous substances with which they are almost always mixed.

But we cannot say the same of earth; for a considerable number of substances are called earths, because they possess the principal properties of the terrestrial element: but these substances, when examined more particularly, are always found to differ from each other so much in other respects, and to be so difficultly purifiable from heterogeneous matter, that we have not ascertained whether only one simple and elementary earth, or several ones essentially different, although equally simple, exist.

The most general and most probable opinion is, that as only one kind of fire, of air, and of water, so only one kind of simple elementary earth, exists. Al-

chemists chiefly have endeavoured to discover this primary earth, not with an intention to ascertain its properties, but because they imagined that as gold is the purest of metals, the earth of which it is partly composed must be also the most pure; they have, therefore, searched every where for this earth, which they call *pure earth* and *virgin earth*. They have endeavored to obtain it from dew, rain, the air, ashes of vegetables, animals, and several minerals: but it was impossible to find it in compound bodies; for we shall see that when once this element makes part of a compound body, it cannot be disengaged from the substances with which it has united.

Some of the best philosophical chemists have rather chose to admit different kinds of elementary earths, than to investigate the nature of the most simple and elementary of all. Becker admits three principles, which he calls *earths*, namely, *the vitrifiable*, *the infusible*, and *the mercurial earth*, which are known by the name of *the three earths of Becker*.

Mr. Pott, examining the principal natural earths, divides them into four kinds, *the calcareous*, *the calcareous*, *the argillaceous*, and *the gypseous earths*. This able chemist shews the essential properties of these four kinds of earths, without affirming that they are all equally simple, and without even determining which of them he considers as most simple.

As earth is an element which enters into the composition of almost all bodies, and which seems chiefly to affect their properties, it deserves an accurate investigation to discover which is the most simple and elementary of all the substances to which the name *earth* has been applied. This subject seems capable of decision by considering, first, what are the essential properties by which earthy substances differ from other elements, and then by determining that earth to be the most pure and simple, which possesses these properties most eminently and decisively; for we cannot doubt, that the properties distinguishing earthy matters from the other elements are the essential and specific characters of the earthy element; and also, that the more eminently any substance possesses these characteristic properties of the earthy element, the nearer it approaches to this element, considered in its state of purity and simplicity.

This being established, if we compare with the other elements all the substances which may reasonably be considered as earthy, we shall soon be convinced, that these possess much greater *weight*, *hardness*, *fixity*, and *infusibility*, than any other element; for these qualities are insensible, or do not exist, in the element of fire; they are in an exceedingly small degree in the air, and are more sensible and considerable in water; but are infinitely less than in any thing which can be considered as earth. Hence we ought to conclude, that the qualities above-mentioned are the distinguishing and characteristic essential properties of the earthy element. But these qualities are not so eminently united in any of those substances which are considered as earthy, as in that which is called by chemists, *vitrifiable earth*. We say then, that this earth is the heaviest, hardest, most fixed, and most infusible, and even the most *aperyous* of all earths, when it is very pure; and also that it is the most homogeneous, the most simple, and elementary earth, as we shall prove by a more particular examination of its properties, and by a comparison of these with the properties of the other earthy substances.



We call that *vitrifiable earth*, the integrant parts of which when united form masses of matter or stones, absolutely white and colorless, much more transparent and hard than any other natural substances, and which suffers no alteration, or even fusion, by the strongest fire which we can apply to it.

Amongst the hard stones called vitrifiable, we indeed know few which strictly possess all the qualities we have mentioned; because in very few of them the vitrifiable earth is pure. Most of these stones, as hard pebbles of all kinds, sand, free-stone, agates, quartz, rock-crystal, and the stones called precious, are deficient in some of the qualities required to constitute the pure vitrifiable earth. Some of them are opaque, or only semitransparent; others are colored; some are fusible by a great heat; and, lastly, others, although much harder than any other kind of stones, want the last degree of hardness; all which prove that they are mixed with heterogeneous substances, chiefly phlogistic, metallic, or even earthy, of a different kind.

The purest of all the vitrifiable stones is the diamond, which is perfectly white, free from all color or stain, and transparent. This stone is also known to be the hardest of all, is absolutely apyrous, that is, incapable of receiving any alteration by the most violent heat. We, therefore, consider the matter of this stone as the purest, simplest, and most elementary earth that is known. The properties, then, of this stone, and of the other vitrifiable stones which resemble it, may give us notions of the properties of primary, elementary, uncharged earth. In this our opinion is conformable to that of the illustrious Stahl, who indeed admits the three earths of Becker; but, at the same time, corrects the theory of this chemist, by declaring that he only considers the first earth of Becker, or vitrifiable earth, as the proper terrestrial or earthy element. *Specimen Beckervianum*, p. 44. No. 25.

But before we particularly enumerate the properties of this earth, we ought to make some observations on those hard, earthy, and stoney matters called by chemists *vitrifiable*.

Our first observation shall be concerning the name *vitrifiable earth*; because it may produce false notions of the nature of these stones.

We say then, that the epithet, *vitrifiable*, is given, first, because some stones of this kind are, by means of their heterogeneous matters, capable of fusion and conversion into glass, without addition, and merely by the action of a very violent heat; and secondly, because other stones of this kind, which are less fusible than these now mentioned, but which are yet more so than stones of other kinds, require for their perfect fusion and vitrification a less quantity of flux, and a less degree of heat.

In the second place, as all the earths and stones called vitrifiable have, notwithstanding their impurity, more hardness and transparency than others, and are fitter to communicate these good qualities to glass, they are employed preferably to any other earths in the composition of glass, or artificial crystal. These are the only reasons why this kind of earth has been called vitrifiable. But we ought not from thence to conclude, that the earthy substance which abounds entirely composes them is more fusible and more vitrifiable than other earths; on the contrary, I again say, that vitrifiable earth, when very pure, is of all earths the least fusible, and the least vitrifiable. I was present at a fine experiment made relatively to this subject. Some diamond powder was mixed with a

sufficient quantity of fixed alkali to vitrify any other earthy matter, and the mixture exposed to a heat sufficient for the most difficult vitrifications. After the operation, no glass was found in the crucible; but part of the alkali had been dissipated by the violence of the heat, and the diamond powder did not shew any signs of a beginning fusion. Thus we may consider it as an established truth, that the earths and stones called vitrifiable are not essentially and really so; that the fusibility of some of these, by which property they are rendered the fittest earths for vitrification, proceeds from heterogeneous matter with which they are mixed; and that, in general, the whitest, clearest, most transparent and hardest of these stones are also the most refractory and unfusible. *See VITRIFICATION.*

Our second observation shall relate to the weight of vitrifiable earths. We have already said, that the purest and simplest of all earths ought to be also the heaviest; and accordingly we find that pure vitrifiable earth is specifically heavier than calcareous, argillaceous, gypseous, or other earths. We are, nevertheless, no less certain, that metals, metallic earths, and several kinds of spars, both calcareous and selenitic, are much heavier than the most compact vitrifiable stones: but we must consider that these earthy matters are very compound bodies in comparison of the purer earths. An objection may be made, that if elementary earth be essentially the heaviest of all matters, then any body compounded of this earth and other matters ought to be lighter than pure earth. This objection would be unanswerable, if the specific gravity of a body was always equal to the specific gravities of the integrant and constituent parts which compose it: but as these parts may be so arranged that void spaces may be left betwixt them, sometimes larger, and sometimes less, therefore a body composed of parts essentially lighter, may yet have a greater specific gravity than another body whose parts are essentially heavier; and this happens in all metals and metallic matters. *See METALS and METALLISATION.* Thus the gravity of metals and of metallic earths and stones ought not to prevent our considering the pure and elementary earthy principle as the heaviest of all natural substances.

After these explanations, we may consider the properties of elementary earth in the purest vitrifiable stones, and may compare them with the properties of the other elements. Since of these elements water is the most capable of our examination, we shall compare it with the purest vitrifiable earth; observing always, that we consider these elements in their state of aggregation; for we have no method by which their primary integrant parts can be known and considered separately.

If then, on one side, we consider a mass of water, absolutely pure, exposed to a cold sufficient to form it into hard, compact, solid ice; and if, on the other side, we compare to this a mass of vitrifiable earth, as a diamond, or even a very fine and clear rock-crystal, we shall easily perceive that these two matters resemble perfectly each other in their appearance; we shall find that both of them are colorless, inodorous, and tasteless; and that their transparency is alike: therefore, if we could no further examine their properties, we must consider them as being of the same matter: but when the other properties of these substances are examined, as weight, hardness, fusibility, and fixity, then we shall perceive differences, which indeed are only in the degrees of these properties possessed

possessed by each of the two substances: but the difference of these degrees is very great. Thus the specific gravity of rock-crystal is almost four times that of ice: their hardness also is so different, that the earthy substance resists the point of the hardest steel, without being scratched; and when struck by steel, elicits ignited sparks; while ice may be easily cut by instruments of steel, and does not elicit sparks when struck: their difference of fusibility is still more sensible, the ice becoming fluid by a gentle warmth, which does not sensibly affect rock-crystal in any respect. I say, *sensibly*; because with the least diminution of cold it is certainly somewhat affected, so far as to be expanded, and consequently to be less hard and heavy. But these two latter affections, particularly, are so inconsiderable in a vitrifiable stone with the heat necessary to thaw ice, that probably it cannot be estimated. Lastly, if we continue to examine these two substances, by a heat gradually augmented, we shall see the water totally dissipated in vapors, before even either of these substances has become red-hot, and the vitrifiable stone support a heat almost infinitely increased, till it is white and dazzling, without becoming fluid, or without any part of it exhaling in vapors; for it may be afterwards found to have lost no weight by having been exposed to this heat.

So far we can extend our examination; for I do not believe that a pure vitrifiable earth, as a diamond, can be fused even in the focus of the best burning speculums: but supposing that a sufficient heat might be produced to procure this fusion, or that this stone were exposed to infinitely greater heat, such as we conceive to be in the body of the sun, it would then melt, and would even be reduced to vapors, if the heat were sufficiently violent; and when this heat should cease, it would, when it cooled, fix again, and become such a substance as it was before. The same would happen to vitrifiable earth in these circumstances, which does happen to water rendered fluid, and reduced to vapor by a certain heat, and which is again frozen into solid ice when that heat is removed. The differences, therefore, betwixt these two substances are only, as we have already said, in the degrees; but also these differences are very considerable.

From these considerations an inference seems deducible, that the elements or the simplest substances which we know are essentially only one and the same matter, and only differ from each other in the quantity and in the form of their primary integrant molecules, which, from this difference of form and quantity, have a greater or less tendency to unite together; and we might be inclined to believe that a certain kind of analogy or gradation exists betwixt them: thus, for example, that earth should be to water, what water is to air, and what air is to fire, or rather to some unknown intermediate substance betwixt air and fire; for the difference betwixt these two latter elements appears too great to be compared with the differences amongst the three former. But these are speculations entirely systematic; for we are very far from being capable of estimating the essential properties of elements sufficiently exactly, to be able to determine any thing precisely and positively in this respect.

However that may be, we cannot doubt but that earth chiefly differs from the other elements by the powerful tendency which its parts have to each other, and by the force of their cohesion. For its hardness, fusibility, fixity, and even its gravity, are evidently the necessary consequences of this principal and essential property. And by this property does the earthy element act in the system of nature. By this it is the cause of the consistence of all solid bodies.

It receives, fixes, and incorporates in some measure the other elements.

Lastly, as without fire the whole world would be one mass of solid and immoveable matter, so without earth it would be a confused heap of fogs, vapors, a chaos of incoherent atoms, destitute of that harmony and equilibrium which sustain it.

We have already had occasion to shew in several parts of this work, that the general tendency of the parts of matter to each other is the grand spring of the universe; that by this power, all combinations, solutions, and, in a word, all the movements and operations of nature are performed: and as we have shewn that the earthy element possesses this tendency in the greatest degree, we ought to consider earth as being in this sense the most active and powerful of all elements. This notion is contrary to the opinions of chemists and philosophers, who from not having sufficiently examined this subject, and being deceived by the seeming inactivity of earth considered in its state of aggregation, have affirmed it to be an element purely passive, and only capable of impulse from other elements. Indeed when the parts of earth are united together, they appear to be, and really are, incapable of acting upon other bodies, because they then exhaust all their action mutually upon each other. But the force with which they adhere together, and which renders them incapable of forming other unions, the extreme hardness and insolubility of a mass of pure earth, ought to demonstrate to a true philosopher, that if we suppose the parts of earth so separated from each other, that they cannot unite, and exhaust their action upon each other, they must then possess all their force of tendency, which must be very great, they must be in a state of violent effort, and consequently must tend with extreme force to unite with any parts of matter which may be within their reach, and to which they can apply themselves. We do not indeed know any pure earth which is in this state of broken aggregation: but we know compounds in which the primitive integrant parts of the earthy element are only combined with the parts of water, which are incapable of satisfying all their tendency to union. These are the most simple saline substances, such as acids and alkalis; and we may judge by the force and vehemence of the action of these solvents, how violent the action of the parts of earth would be, which should be capable of exerting all the attractive force which belongs to them.

Although the entire mass of our globe be probably formed by an immense heap of elementary, vitrifiable, and even actually vitrified earth, as the illustrious Buffon believes, we do not find upon its surface but a very small quantity of this earth, unaltered, and in its primary state. Perhaps even none of it exists in that state: for, as we have observed, the common vitrifiable stones, which are chiefly formed of it, are very far from the degree of purity of primitive elementary earth; and even perfect diamonds, which seem of all these stones to approach the nearest to this purity, seem to have been elaborated by the waters, if we can judge from their regularly crystallized form.

We shall not be surprized at the scarcity of pure earthy element, if we consider that the surface of the earth, which alone we are acquainted with, has been from the beginning of the world exposed to the constant action of the other elements; and that by uninterrupted operations, nature, assisted by  
fire,

fire, air, and water, has gradually disunited the integrant parts of elementary earth, and by combining them in manners and proportions infinitely various with parts of the other elements, has formed the numberless compound bodies, which occupy a certain thickness near the circumference of the globe, probably very small in comparison of the diameter of the earth, but very large with regard to us, whose greatest efforts only extend to a few hundred feet below its surface.

All the portions of elementary earth, which, having been thus disunited, have afterwards been combined with parts of matter of other kinds, have received very sensible changes, the effects of which always remain, and prevent them from appearing afterwards, notwithstanding future decompositions, in their original purity and simplicity. They then assume different forms according to the nature of the compounds into the combination of which they have entered. Thus, for example, the earth which makes parts of crustaceous animals, or rather of their shells and scales, takes the character of that earth which is called *calcareous*, and which is capable of conversion into quicklime by the action of fire. The earth which has entered into the composition of plants, and even of the bodies of animals, after having been deprived as much as is possible of the principles of these compounds to which it was united, forms all the *argillaceous earibs*. Some of these are found which partake both of the calcareous and of the argillaceous properties, and are called *marles*. Marles have not yet been sufficiently well examined by chemists. They are either a mixture of clay and calcareous earth, or they have been so elaborated by nature as to be transformed into a particular earth, partly calcareous, and partly argillaceous, such as the earth of animal bones seems to be.

As the earth which forms sands and the common impure vitrifiable stones retains more than the rest the essential properties of elementary earth, notwithstanding the heterogeneous, phlogistic, and other parts with which it is mixed; we cannot easily know whether it has once made a part of some very compound bodies, from the principles of which it has been more perfectly separated than the argillaceous and calcareous earths; or whether it be the primitive earth, which, without having made part of any intimate combination, has only been divided and conveyed by waters, and the parts of which have afterwards reunited, having only contracted a slight union with some phlogistic, metallic, and other matters, with which it is found mixed. This latter supposition appears to me to be the most probable. But very extensive researches in natural history and in chemistry are requisite to determine this question.

From what we have said concerning the principal kinds of earths which form the surface of the globe, we may conclude, that excepting the purest vitrifiable earth, all the others are mixed with heterogeneous matter. By these remaining heterogeneous matters are the different kinds of earth specified and characterised: and as they all preserve and retain their peculiar character, we ought to conclude from thence that these extraneous matters are very intimately united. To purify and simplify these mixed earths, so that they shall be assimilated to the purest vitrifiable earth, would be a fine problem. But, probably this problem is beyond the power of our art. For as in general

the perfect separation of two substances, united together, is exceedingly difficult, this difficulty must greatly increase, when one of the two substances to be separated has a very strong attractive power, as earth has. This is the true reason why we find so small a portion of pure earth amongst the bodies within our reach; and that on the contrary, the globe is covered with so great a quantity of earthy substances differing from each other so much, that we might be inclined to believe them to be bodies essentially different. *See the articles, EARTH (CALCAREOUS), EARTH (VITRIFIABLE).* (u)

# CCXLVI. EARTH (ANIMAL). (x)

(u) In this article the author has advanced some ingenious speculations, but in my opinion several of his propositions are affirmed without proof, and some of his inferences are not conclusive. The subject does not appear to me capable of being treated so decisively. Most philosophers, ancient and modern, have enumerated, according to their theories, the *elements* of which they believed all substances to be constituted. Nevertheless, they have not yet proved the existence of any one element. The impossibility even of such a proof appears from considering, that the only reason which can induce us to believe that any substance is an element is, that we are incapable of decomposing that substance; and that our incapacity to decompose does not necessarily imply an impossibility of decomposition. The improbability of the conjecture that fire, air, water, earth, are the only elements, might easily be shown. If we mean by element whatever substance we are incapable of decomposing, (and this is the only precise meaning which can be formed of it) then many other substances are entitled to be enumerated amongst elements. According to this meaning the number of elements will decrease, when means of decomposing some of those which cannot now be decomposed are discovered. The author believes that only one kind of elementary earth exists, and he further believes that this earth is that which he and some other authors call *vitrifiable*. But besides that the class of earths called vitrifiable contains many substances, the properties of which are exceedingly different, no proof can be given that those substances which are believed to be the purest of this class of earths, as diamonds, are more simple and elementary than calcined calcareous earths, argillaceous earths, earth of magnesia, metallic or many other earths; all

which, when purified by ordinary methods, are as incapable of decomposition as diamonds are, and consequently as well entitled to be considered as elementary.

Earths are divided by Mr. Pott into vitrifiable, argillaceous, calcareous, and gypseous. The author of the Dictionary follows this division. Other authors have invented other divisions, and enlarge the number of classes, by which their dispositions are more comprehensive and distinct.

But although these arbitrary arrangements of natural substances may assist learners, yet as they are all very imperfect, our knowledge will be also very imperfect, unless we consider separately each species. In the notes to this Dictionary, therefore, the chemical properties of each species, as well as of the genera and classes of earths, (in which are comprehended, not only substances, commonly called earths, but also stones, slates, spars, and talcs) shall be mentioned as the names of these species occur in the alphabetical order.

(x) EARTH (ANIMAL) is the earth of shells of animals, or that which is obtained by calcination or putrefaction of animal substances. 1. The *earths of the shells of Sea Fishes* have the general properties of calcareous earths. *See EARTHS (CALCAREOUS).* It differs from the mineral calcareous earths in being difficultly soluble by vitriolic acid, and in being less disposed to vitrify along with salts and metallic glasses. The *shells of eggs* are also calcareous, but are somewhat fusible by fire. 2. The *earths of calcined bones and horns* are soluble by nitrous, marine, and vegetable acids, and with difficulty by vitriolic acid; but are not calcareous. They are said to be unfusible, even when mixed with salt, metallic glasses, and other fusible mixtures. They are therefore used in the composition of enamels and opaque white glasses.

CCXLVII. EARTH (ARGILLACEOUS). See CLAY.

CCXLVIII. EARTH (CALCAREOUS). Chemists have given this name in general to all earths and stones, which being burnt acquire the properties of quicklime.

Nature presents to us a considerable quantity of calcareous earths and stones, which have peculiar differences depending on their greater or less purity, but which resemble each other by essential properties common to all, and particularly by their capacity to receive calcination.

The principal kinds of these earths or stones are, chalks, all the calcinable shell-stones employed for building, all marbles, calcinable stalactites, the alabasters and spars which are convertible into quicklime by fire.

Amongst these stones a great number are evidently impure and mixed, particularly those which are colored. But amongst the whitest, we cannot easily ascertain which of them contains the purest earth, because they have not been chemically compared with this view. We ought certainly to consider those as the purest which possess in the highest degree the essential properties of calcareous earth.

All calcareous stones are less hard than vitrifiable stones; none of them strike fire with steel, and they all may be easily cut with steel instruments; some of them may be found, whose parts having been divided, conveyed by waters, and afterwards deposited successively upon each other, form concretions, or rather crystallizations, very near and even transparent. Their transparency however is always less than that of the purer vitrifiable stones.

The specific gravity of the different kinds of calcareous stones has not been compared with the specific gravity of the vitrifiable. We only know that some calcareous spars are much heavier than the precious stones, and are therefore called *heavy spars*. But as we are very certain that the weight of these bodies is caused by extraneous and not calcareous matter, this does not prevent our establishing a general rule that calcareous earth is less heavy than vitrifiable; for, excepting the instance now mentioned, they all are so.

If any calcareous earth or stone be divided by trituration and moistened with water, it absorbs a certain quantity of it, particularly if it be very dry; and it forms a kind of paste, the parts of which have a certain adhesion together. But this paste is not so ductile as that formed by clay and water. It also dries and disunites much more quickly.

glasses. Nevertheless, Wallerius affirms, that the earth of calcined bones, by intense heat, was changed, without addition, to a green glass. See *Mém. Suéd.* 1760. The same author says, that the earth of the whites and yolks of eggs was easily fusible, and that in general the fusibility of animal earths is in proportion to the softness of the parts from which they were obtained. 3. The earth of blood, flesh, and skins of animals, is soluble by all acids, and is fusible by fire; that of blood

and of other animal fluids being most fusible. This earth, like that of burnt bones and horns, is not calcareous; but both these kinds of earth are said to be rendered calcareous by being dissolved in acids, precipitated by fixed alkali from those acids, and afterwards calcined. They probably contain some oleaginous substance, from which they cannot be entirely divested by fire without a previous solution in acids.

All acids are evidently capable of acting upon calcareous earth; they attack and dissolve it with more or less effervescence. This action of acids upon calcareous earths and stones furnishes us with an easy method of distinguishing them from other earth and stony matters, which they resemble externally.

Calcareous earth saturates all acids, and forms with them different *neutral salts with bases of calcareous earth*, according to the kind of acid.

With vitriolic acid, it forms a crystallizable salt, not very soluble in water, called *Selenites*.

With nitrous and marine acids, it forms acrid, bitter, and very deliquescent salts. They are called *nitre*, and *marine salts with calcareous bases*.

With the acid of vinegar, calcareous earth forms a salt not deliquescent, and susceptible of a silky and ramose crystallization like a kind of vegetation. This is *acetous salt with calcareous basis*.

Lastly, with acid of tartar, this earth forms a neutral crystallizable salt, a *soluble tartar with calcareous basis*. This salt is much more soluble in water than pure acid of tartar.

Calcareous earth has also the property of decomposing all ammoniacal salts, from which it disengages the volatile alkali, and unites with their acids, when assisted by a certain heat.

Calcareous earths and stones, being exposed to the action of fire, lose part of their weight, and much of their consistence, which proceeds from the fire carrying off a considerable quantity of water which enters into their combination; and as the last portions of water are powerfully retained by earth, a very strong heat is requisite to dissipate them; and in this principally consists the change produced upon calcareous stones when reduced into quicklime. See QUICK-LIME.

The most violent fire we can make is incapable of melting and vitrifying calcareous earths and stones, when they are very pure (y); but a very remarkable thing is, that these substances, so refractory when alone, become true fluxes, and facilitate the fusion and vitrification of several other substances, as sands and clays. This phenomenon, the cause of which is hidden, and not easily to be discovered, seems to depend on a particular disposition of the inflammable principle from which none of these matters is entirely exempt, and perhaps on some remaining portion of watery principle, so strongly retained by calcareous earth, that fire cannot entirely extricate it. See VITRIFICATION.

The other characteristic properties of calcareous earth are the same as the properties of this earth when converted into quicklime, which we shall relate and explain under the article QUICKLIME. We shall only here observe, that if we add to these the properties of calcareous earth before calcination, we shall evidently see that all these properties, and the phenomena arising from them, depend on the intimate union of a certain quantity of watery principle with the earthy principle in calcareous earth; an union which produces an incipient saline combination, according to Stahl's theory, and a strong disposition in cal-

(y) Mr. D'Arcet found that chalk, lime-stone, and one calcareous spar, resisted a violent, long continued heat; but that other spars, stalactites, and other calcareous sub-

stances, shewed a beginning fusion. See *Mem. l'Acad. des Sc. sur l'Action d'un feu violent, égal, & continué*, 1766.



calcareous earth to pass into a more compleat saline state by a more perfect combination with water. We may hence easily perceive, that as calcareous stones in their natural state do not differ from vitrifiable stones but in being less hard, less heavy, and less fixed, which are precisely the essential qualities by which pure water differs from pure earth; that as, besides the action of fire deprives calcareous stones of much water, calcareous earth chiefly differs from vitrifiable earth by its union with water; and lastly, that as we cannot doubt but that all calcareous earth has been once one of the principles of organised animal bodies, we cannot also doubt, but that the water, the portion of phlogiston ( $\alpha$ ), perhaps also some remaining small part of saline matter, which are found in these earths, and which distinguish their different kinds, are the remains of the principles with which the elementary earth was found combined in these compounds, and which continue firmly united with them. ( $\alpha$ )

**CCXLIX. EARTH (GYPSEOUS).** This name is applied by some chemists to gypsum, and to the earth contained in klenites. As the

( $\alpha$ ) Most, perhaps all calcareous earths contain such a portion of phlogiston, as to enable them, by means of heat, to reduce metallic calxes, especially those of lead and bismuth, which are easily reducible, and even in some measure those of copper and iron. By means also of this phlogiston they acquire a phosphoric quality when united with nitrous acid. *See PHOSPHORUS of BALDWIN.* A curious experiment is mentioned by Mr. Pott, which shewed this phosphoric quality of calcareous earth united with nitrous acid. He saturated that acid with quicklime, and distilled it. He repeated this operation frequently, always using the same acid and the same quicklime. He perceived, that the vapors which passed in these distillations through a hole in the receiver appeared luminous sparks, which afterwards kindled, and flowed out like a stream of fire. He also perceived another remarkable circumstance in this operation, namely, that the effervescence which happened on the mixing these two substances, became each time greater than it had been in the preceding experiment. Whence did the quicklime acquire the fixable air which caused these effervescences? Was it from the acid? *See POTT'S Dissertation on Quicklime.*

( $\alpha$ ) *Calcareous earths may be combined with acids, with which they form neutralized earthy salts. See SALTS.* They also readily unite with fixable air, in which state of combination they are always found native. When uncombined with fixable air, or in the state

of quicklime, they may be combined with water, forming lime-water. *See WATER (LIME), AIR (FIXABLE), CREAM of LIME, and QUICKLIME.* In this uncombined state they also may be united in some degree with sulphur, forming a kind of hep-  
par of sulphur, and imperfectly with oleaginous substances forming kinds of soaps.

Calcareous earth, although infusible by fire (*see the above note [y]*), may be rendered fusible and vitrescible by addition of fixed alkaline salt, of borax, of sedative salt, of salt of urine, of metallic calxes, of gypseous and argillaceous earths, of fusible spars, and according to Mr. Pott, of sparry quartz, of glass-gall, and of fixed ammoniac. Mr. Gellert, in his Table of Solutions, places calcareous earth amongst the substances incapable of uniting with gypseous earths. Nevertheless, the experiments of Mr. Brandt and of Mr. D'Arcet evince the fusibility of calcareous earths mixed with gypsum. This however may be observed, that I have found from experiments, that such mixtures are fusible only when exposed suddenly to a violent fire, and that by a gradually raised fire they are calcined into quicklime. The cause of which seems to be, that the vitriolic acid of the gypsum is necessary to the fusion; and that this acid, by a long continued heat not sufficiently intense to occasion a fusion of these two earths, may be dissipated, leaving its calcareous basis behind, which together with the calcined earth forms an unfusible mass or quicklime. \*

earth of gypsum, when separated from the vitriolic acid, does not appear to be different from pure calcareous earth, we refer to the articles GYPSUM, SELENITES, and EARTH (CALCAREOUS).

CCL. EARTH (MERCURIAL). Mercurial earth is a substance, which, according to Beccher and other chemists, enters into the composition of many bodies, particularly the metallic, together with *vitrifiable earth*, and phlogiston, which that chemist calls the *inflammable earth*. But the existence of this mercurial earth has not yet been satisfactorily demonstrated. Metals and marine acid, of which also Beccher supposes the mercurial earth to be a constituent part, do indeed present some phenomena which may induce us to suspect that these substances contain a principle different from all those which we know. But these phenomena are not sufficient to establish with certainty the existence of this principle. *See what is said on this subject under the articles ACID (MARINE), MERCURIFICATION, METALS, and METALLISATION.*

CCLI. EARTH (VEGETABLE). (*b*)

CCLII. EARTH (VITRIFIABLE). The earth so called by chemists is the purest, simplest, and most elementary of all known earths. As we have mentioned all the essential properties of this earth under the general article EARTH, we refer for these properties to that article. We shall only observe here, that the stones formed principally by the union of the parts of this earth, and therefore called vitrifiable stones, are easily distinguished from all the others by their hardness, which is so great, that they cannot be cut by steel tools, and that they can elicit sparks from steel. They have also the property of giving sparks of light when one of them is struck against another; but it is then an internal fire, and ignited sparks are not emitted, as when they are struck by steel. This property of giving light by percussion also belongs to glass, porcelaine, and other vitrified matters. It seems to be a phenomenon depending on electricity.

(*b*) EARTH (VEGETABLE). From numerous experiments made by Wallerius we find that earths or ashes of vegetables have not all the same chemical properties, but may be reduced into three kinds or classes. The first class is the earth obtained by burning soft, spongy, and farinaceous plants. It is partly soluble by vitriolic acids. It is more fusible by fire in proportion as the plant from which it has been obtained was more nourishing. Thus the ashes of rye, barley, oats, mustard, and especially those of wheat and rice, were easily fusible, forming green transparent glasses. This fusion is not occasioned by any mixture of alkaline salt, for no such salt could be obtained from the ashes of the above-mentioned grains by lixiviation. The second class of vegetable earths is produced by burning the harder and less succulent plants. This earth is more solu-

ble than the former in nitrous and marine acids, but is less soluble in vitriolic acid. This earth, after lixiviation, still absorbs moisture from the air. It is also fusible by fire, but not so easily as the former earth, and is less fusible in proportion to the hardness of the plant. The third class of vegetable earth is that which is obtained by burning wood. This earth is calcareous, and is more difficultly fusible in proportion as the wood from which it was obtained was harder. Accordingly, it has been observed by manufacturers of glass, that ashes of the hardest woods make the most unfusible glass. Garden mould, which consists chiefly of the earth of decayed vegetables, was also found to be fusible by fire. *See the Swedish Memoirs for the year 1760.* By putrefaction of vegetable substances, a calcareous earth is said to be obtainable.

Vitrifiable

Vitrifiable earth, when pulverised into very fine parts, and moistened with water, absorbs but a very small quantity of this liquid, and forms a paste which has considerable adhesion, but no ductility. When it is made thin by water, it pours like an oily or viscid matter: when it is of a thick consistence, it does not preserve the form given to it, but it sinks and collapses: it also dries very quickly and easily. If, on the contrary, this finely ground vitrifiable matter be left at rest under water, its parts will unite and adhere together so strongly, that a mass shall be formed almost as hard as a stone. Hence when vitrifiable stones are ground with water, the matter must be continually agitated and stirred, and the mill must be turned without interruption; for if they are left but a little at rest, they harden, and adhere so strongly to the bottom of the mill, that the mill-stone cannot without difficulty be again set in motion. This inconvenience may be much diminished by mixing the vitrifiable earth to be ground, with different earths, calcareous or argillaceous.

No vitrifiable stone or earth is soluble in any acid, unless its nature has been changed by having been intimately united with some other substance; as, for instance, by fusion with a sufficient quantity of fixed alkali: but it cannot then be considered as pure vitrifiable earth, as it has not then the properties of that earth.

As some stones externally resemble vitrifiable stones, and which also resist the action of acids, although they are not vitrifiable, the proof by acids is not sufficient to ascertain the nature of these stones. To this proof must also be added that of hardness, which is the most decisive. Many impure and mixed vitrifiable earths and stones differ from each other by their colors, and other accidental particulars depending on the heterogeneous matters with which they are united.

Nature presents to us many mixed earths and stones, or such as are composed of many kinds of different earths, as the vitrifiable, calcareous, talky, argillaceous, gypseous or selenitic, and even the pyritous or metallic. But we cannot enter into these details, which are the object of mineralogy. We shall observe, that when an accurate examination of these compound bodies is required, the nature and proportions of the component parts may be discovered by submitting them successively to the decisive proofs which we have mentioned under the articles of the principal kinds of earths and stones, by which their nature may be discovered and ascertained. *See in particular for the vitrifiable earths and stones, the general article EARTH, and the word VITRIFICATION.*

### CCLIII. EARTH-WORMS. (c)

(c) EARTH-WORMS. Earth-worms, when moistened with wine, or with vinous spirits, to prevent their putrefaction, and set in a cellar in a wide-mouthed vessel, are in a few days almost wholly resolved into a slimy liquor. Stahl supposes that they are impregnated with a nitrous salt which they receive from the putrid matters amongst which they live. When this liquamen of worms is mixed with a little fixed alkali, and, after the evaporation, is set to shoot, the crystals are nothing else than nitre, Six drams of extract

were obtained by ardent spirit from four ounces of worms; and from the same quantity of these, one ounce, six drams, and a scruple of extract, by means of water. Thirty-two ounces of dried earth-worms yielded, by distillation, thirteen ounces and a half of volatile urinous spirit, one ounce of concrete volatile salt, four ounces and a half of empyreumatic oil, and eight ounces of a residuum, from which were obtained, by calcination and lixiviation, an ounce and a half of fixed alkali. *Neumann.*

**CCLIV. EAU DE LUCE.** Eau de luce is a kind of volatile, liquid soap, of a strong, penetrating smell.

This liquor is composed of the liquid volatile alkali made from sal ammoniac with quicklime, and of the rectified oil of amber, so mixed together as to produce a white milky liquor.

Eau de luce cannot be prepared without certain management; for if the volatile spirit of sal ammoniac and rectified oil of amber be simply mixed and shook together, a milky liquor will be produced, such as is required; but this color disappears soon when the liquor is allowed to rest; either because the volatile alkali completely dissolves the oil of amber when in small quantity, or because this oil disengages itself from the volatile alkali, and floats a part when in considerable quantity. In both cases the liquor becomes clear and transparent; but the milky color is required in eau de luce. By the following receipt excellent eau de luce may be made.

Take four ounces of rectified spirit of wine, and in it dissolve ten or twelve grains of white soap; filtrate this solution; then dissolve in it a dram of rectified oil of amber, and filtrate again; mix as much of this solution with the strongest volatile spirit of sal ammoniac, in a crystal glass bottle, as when sufficiently shook, shall produce a beautiful milky liquor. If upon its surface be formed a cream, some more of the oily spirit of wine ought to be added.

This receipt is given by the author of the French edition of the London Dispensatory. The receipt given in that work is very good, but is much improved by the observations, experiments, and remarks made by that author.

**CCLV. EDULCORATION.** Edulcoration is, properly speaking, the rendering substances more mild. Chemical edulcoration consists almost always in taking acids and other saline matters from substances to which they adhere; and this is effected by washing in much water. The washing of diaphoretic antimony, and of the powder of algaroth, till the water comes off from these substances quite pure, may be given as instances of edulcoration.

In Pharmacy, juleps, potions, and other medicines, are said to be *edulcorated*, by adding sugar or syrup.

**CCLVI. EFFERVESCENCE.** Effervescence is an intestine motion excited betwixt the parts of two bodies of different natures, when they reciprocally dissolve each other. Effervescences are commonly accompanied with bubbles, vapors, small jets of the liquid, and noise or hissing. All these phenomena are occasioned by the air which disengages itself in almost all solutions. Frequently also effervescences are accompanied with a considerable heat, sometimes exceeding that of boiling water. This heat is occasioned by the collision of the parts during their union. The degree of heat produced in effervescences is proportionable to the activity with which bodies are dissolved, to the quickness with which the solution is made, and to the quantity of substances re-acting upon each other.

The most sensible effervescences are observed in the combination of concentrated mineral acids with calcareous earths, alkaline salts, metallic substances, and oily matters.

Generally the substances which contain a sensible quantity of inflammable principle are those which in similar circumstances produce the most heat in effervescing.

effervescing with acids. Of all acids, the nitrous produces the greatest heat, when it dissolves these bodies.

Thus, for instance, the heat arising from a solution of calcareous earth in nitrous acid is not nearly so great as that which arises from a solution of a metallic substance in the same acid, although these solutions are performed equally fast; and the heat which is produced by the combination of nitrous acid with oils is so great, that a flame is quickly produced.

Formerly the word *fermentation* was commonly applied to effervescences; but now that word is confined to the motion which is naturally excited in animal and vegetable matters, and from which new combinations amongst their principles take place. This distinction is very proper; for a simple effervescence is very different from a true fermentation. See FERMENTATION.

CCLVII. EFFLORESCENCE. By this expression chemists denote what happens to certain bodies, upon the surface of which a kind of meal or powder is formed.

Efflorescence is occasioned either by decomposition or by drying. That which happens to Cobalt, and most martial pyrites, is of the former kind; and the efflorescence observed on crystals of marine alkali, of Glauber's salt, of alum, of green and blue vitriols, and of several other salts, is of the latter kind.

CCLVIII. E G G S. The eggs of hens, of birds in general, and of several other animals, are composed of several distinct substances; 1. Of a shell or external coat, which in the eggs of birds has a certain hardness and consistence, although it is brittle. The matter of this shell is a fine, absorbent earth, soluble in acids; hence if these eggs be steeped in vinegar, or any other acid, they are rendered quite soft, because the acid dissolves and takes away all the earth of their shells. (d)

The parts of this earth are bound together by a small quantity of gelatinous matter. This matter becomes very sensible by an empyreumatic animal smell, and by the black color which shells acquire when exposed to fire.

The shell of an egg is lined internally with a very white, fine, and strong membrane. It resembles a very fine skin, and is entirely of animal nature.

These external coverings contain the substance of the egg, which is of two kinds; namely, a lymphatic, white, transparent, gelatinous, viscous, and gluey substance, called *the white of the egg*; and another substance also gelatinous, but almost opaque, yellow, less gluey and viscous than the white. This latter, which is called *the yolk*, is of a spherical form, and is surrounded by the white. To the yolk is annexed a small portion of white gelatinous matter, thicker and tougher than the rest of the white in which the embryo is contained.

We do not intend here to examine anatomically the uses of these several parts of the egg; we will consider them only relatively to their chemical properties and principles. As eggs contain the embryo of the animal, and the nourishment proper for it in its first increase, they are proper to give as an example of the analysis of animal feed.

(d) The shells of eggs are not only absorbent, that is, soluble by acids, but also calcareous, or convertible into quicklime. The earth of the shells, and also the earth obtained by calcination of the other parts of the eggs, are fusible and vitrescible by fire. See EARTH (ANIMAL).

The white of an egg cannot be dissolved by acids or by spirit of wine. This latter solvent, far from dividing it, on the contrary coagulates it, by taking from it a great part of its water which renders it liquid.

The white of an egg is soluble and miscible with water, but difficultly, because of its viscosity. Spirit of wine poured into water which keeps it dissolved separates it, and precipitates it in form of a curd. In this respect, the white of an egg resembles gummy, mucilaginous, and gelatinous matters. It is, in fact, a matter entirely of the nature of animal jellies, but of that kind which are coagulable by heat. The white of an egg, exposed to a less heat than that of boiling water, is coagulated, hardened, and its transparency is almost entirely changed to a milky-white color. This substance contains no other principles which are volatile with the heat of boiling water, than water; for if whites of eggs be distilled in a water-bath, nothing but water is obtained. While they lose this water, they become more and more hard and horny; they resume their transparency, and acquire a yellow-reddish color; so that when they are dried as much as possible, they perfectly resemble horn.

If they are to be further analysed, they must be put into a retort, and exposed to a naked fire: then fetid empyreumatic oil with much volatile alkali is obtained; and in the retort, when the distillation is finished, a coal is left like that of other animal matters. From this analysis we see that the white of an egg is a perfectly animalised substance. See JELLY (ANIMAL).

The yolk of an egg is chiefly composed of a gelatinous matter like the white; for it also coagulates and hardens by heat; but it also contains a considerable quantity of mild fat oil, which is in some measure superabundant, and not combined, and, in short, in the same state as those oils which may be obtained from vegetable emulsive seeds by expression. Thus the raw yolk of an egg when mixed with water is not entirely dissolved, as the white is; but forms with it, on account of this oily part, a white milky liquor or emulsion. This animal emulsion is vulgarly called *hen's milk*.

This superabundant oil of the yolk of an egg may be separated from it, like that of most vegetable grains, by expression. But to make this operation successful, the yolk of an egg ought to be deprived as much as is possible of its water. For this purpose, the eggs are to be previously hardened, and the yolks are to be separated, dried, and even roasted in a proper vessel, till they become somewhat softened by the sweating out of the oil; they are then to be put into a press, and a fat, unctuous, yellowish, and sufficiently mild oil is procured, which readily fixes itself in the cold. This oil has the smell of roasted or fried eggs, from the drying and roasting given to the yolks before the expression. Probably this oil might be obtained by a slower and more careful drying without roasting, and consequently without any change or smell.

From this quantity of superabundant oil in yolks of eggs, we may perceive a remarkable resemblance betwixt the eggs of animals and vegetable seeds. This oil is found in all seminal matters probably for the same reason. See OILS (SWEET EXPRESSED).

As all eggs in general are composed of a very nourishing substance, and that those of many animals have a very agreeable taste, they have been much used as aliment. They are also employed in medicine and in the arts. The white of an egg is an ingredient in collyriums and cataplasms for diseases of the eyes; and both

both the white and yolk in emollient and resolvent cataplasms. The oil of eggs is softening, relaxing, and lubricating. It is employed either singly, or formed into a pomatum with fat matters, in burns, chaps, contractions, and other similar diseases.

The white of an egg, from its solubility in water, and from its coagulating by fire or in spirituous liquors, is very successfully employed in pharmacy, for many uses of the kitchen, and for clarifying the juices of plants, whey, sugar, syrups, &c. See FILTRATION.

The white of an egg alone forms a varnish very white and very shining, which is applied to several kinds of work, and particularly to pictures. Lastly, the yolk of an egg, from its oily and viscid parts, is a proper intermediate substance for the mixture by trituration of oils with watery liquors, so as to form emulsions. Several good remarks are found upon this subject in Mr. Beaumé's Treatise on Pharmacy. (e)

#### CCLIX. ELECAMPAÑE. (f)

CCLX. ELEMENTS. Those bodies are called by chemists *elements*, which are so simple, that they cannot by any known method be decomposed, or even altered; and which also enter as principles, or constituent parts, into the combination of other bodies, which are therefore called compound bodies.

The bodies in which this simplicity has been observed are fire, air, water, and the purest earth; for by the most complete and accurate analyses which have been made, nothing has been ever ultimately produced but some one, or more, of these four substances, according to the nature of the decomposed bodies.

These substances, although reputed simple, may possibly not be so, and may even result from the union of several other more simple substances: but as experience teaches us nothing on this subject, we may without inconvenience, and we ought to consider, in chemistry, fire, air, water, and earth, as simple bodies; because they really act as such in all chemical operations.

The elements are also called by chemists *primary principles*. See PRINCIPLES, FIRE, AIR, WATER, and EARTH.

#### CCLXI. ELIQUATION. (g)

#### CCLXII. ELUTRIATION. (b)

(e) Mr. Reaumur found that eggs might be preserved during months or years, by being covered with mutton suet, or any other fat substance; which, by filling up the pores of the shell, excluded the air, which is necessary to putrefaction.

(f) ELECAMPAÑE. From thirty-two ounces of the roots of elecampane were obtained, by distillation, three scruples and a half of concrete oil, similar in many, but not in all its properties to camphor. This concrete oil is soluble in spirit of wine. Geoffroy remarks, that it resides in the exterior part of the root, near to the bark. From an ounce of the dry root six drams and a half of extract may be obtained by water, and from the same quantity two drams and a half by spirit.

Neuman:

(g) ELIQUATION. This is an operation by which a more fusible substance is separated from one less fusible, by means of a heat sufficiently intense to melt the former, but not the latter. Thus an alloy of copper and lead may be separated by applying a heat which shall melt the lead, but not the copper.

(b) ELUTRIATION is an operation performed by washing solid substances with water, stirring them well together, and hastily pouring off the water, while the lighter part remains suspended in the agitated water, that it may be thereby separated from the heavier part. By this operation metallic ores are cleansed from earth, stones, and other lighter unmetallic particles adhering to them.

CCLXIII. EMERALD. (i)

CCLXIV. EMERY. (k)

CCLXV. EMPYREUMA. Empyreuma is a smell proceeding from burnt animal and vegetable matters, when they are exposed to a quick fire, particularly in close vessels.

Empyreuma is the peculiar smell of burnt oils. No other but oily substances can produce it. As all vegetable and animal matters contain oil, and as no other substance contains it, hence the empyreumatic smell must be peculiar to burnt animal and vegetable matters; and hence also we may discover oil wherever it may be by this smell, which is so distinguishable, that it is very sensible even when the quantity of oil is too small to be discovered by any other method. If then we perceive an empyreumatic smell when we burn a substance in close vessels, we may conclude that this substance contains oil. If, on the contrary, no empyreuma be perceived, we may be assured that the substance does not contain oil.

CCLXVI. EMULSION. An emulsion is a watery liquor, in which some oily matter is dispersed and diffused (but not dissolved), by the intervention of a mucilaginous or gelatinous substance.

The state of the oil in emulsions is the cause why they are opaque, and of a milky-white color; for this milky appearance is given to all transparent bodies by others that have not a very distinct color, when they are mutually interposed and divided to a certain degree.

Nevertheless, water and oil slightly adhere together in emulsions, by the intervention of the mucilaginous matter; for oil agitated with water gives but a momentary appearance of an emulsion, and only during the agitation. When it is left to rest, the oil presently rises to the surface.

All vegetable and animal substances containing an uncombined oil, and mucilage or jelly, being triturated with water, yield emulsions.

Most seeds and grains, all gum-resins, gummy and resinous juices, and yolks of eggs, are capable of forming emulsions with water. Lastly, the milky juices of plants, milk, and the chyle of animals, ought to be considered as natural emulsions.

(i) EMERALD, *Smaragdus*, is a precious stone, contained by several unequal sides and obtuse angles, forming irregular prisms. Its color is green: with a moderately strong heat it becomes blue, but recovers its original green color when cold. By exposure to collected solar heat, emeralds were rendered white and of various colors, and soon afterwards were fused, by which they lost part of their weight and hardness. See DIAMONDS. Emeralds have the property of shining in the dark after having been heated. They are the fourth in hardness from diamonds; nevertheless they are susceptible of impression from a file. Emeralds may be imitated by adding forty-eight grains of pul-

verised calcined verdegrise, and eight grains of martial crocus, to four ounces of minium and two ounces of pure rock-crystal, previously calcined and levigated, and by keeping that mixture fused during twenty-four hours.

(k) EMERY. *Smeris*. Emery is a very refractory mineral containing a small portion of iron. It is exceedingly hard, and is therefore used for the polishing of metals, glass, and hard stones. Some pieces of emery contain small specks of gold, and of copper. The mineral called by alchemists *smeris Hispanica*, and employed to adulterate gold, is with probability believed to be the metal now called platina.



**CCLXVII. E N A M E L.** Enamel is in general a vitrified matter, betwixt the parts of which is dispersed some unvitified matter: hence enamel ought to have all the properties of glass excepting transparency. Enamels then are opaque glasses, and their opacity and colors proceed from the unvitified matter which they contain. The unvitified matters which give opacity and various colors to enamels, are almost always metallic calxes. Receipts for making several kinds of enamel may be found in several books, particularly in Neri's Treatise on the Art of Making Glass, with Notes by Merret and Kunkel.

Enamels ought to be very fusible. They are employed to color or to paint several kinds of work which are made by great heat. The white enamel is used to cover the earthen ware called *Delf*, to which it gives the appearance of porcelain. With the other colored enamels this *Delf* ware, porcelain, and also the white enamel, are painted. See *DELFWARE*. (1)

**CCLXVIII. E N S M A R T I S, and E N S V E N E R I S.** These Latin names are given to the flowers of iron and of copper made with sal ammoniac, or rather to these two metals sublimed by this salt. See *FLOWERS*.

(1) Enamels are glasses containing some opaque substance, that is either unvitifiable or incapable of being vitrified with the degree of heat requisite for the fusion of ordinary glass. Of the latter sort are almost all the enamels used, they being mostly composed of glass mixed with metallic calxes; all which, not excepting the calx of tin, by more intense heat might be reduced to transparent glasses. The white vitreous composition which is the basis of all enamels is prepared, according to Neri, by melting together a hundred parts of frit of calcined flints, one part of pure salt of tartar, and a hundred parts of a calx of lead and tin. This calx is prepared by calcining together equal parts of tin and lead, and reducing the substance so calcined to a very fine powder, by bruising it, passing it through a sieve, boiling it in water, decanting the water in which the finer parts are suspended, evaporating the water, and drying the powder; and by repeating the calcination and subsequent operations upon the grosser particles, till they become as fine as the former. This composition when slightly fused is to be reduced to a powder, and formed into all the various colored enamels, by adding to it coloring substances. Thus by adding to six pounds of this composition, forty-eight grains of magnesia, a *fine white enamel* may be prepared; an *azurine blue enamel*, by adding to the same quantity three ounces of zaffre, and sixty grains of calcined copper; a *turquoise blue enamel*, by adding three ounces of calcined copper, ninety-six grains of zaffre, and forty-eight grains of magnesia; a *green enamel*, by adding three ounces of calcined copper and sixty grains of scales of iron; a *shining black enamel*, by adding three ounces of zaffre and as much magnesia, or by adding six ounces of red tartar and three ounces of the same magnesia; a *purple enamel*, by adding three ounces of magnesia; a *yellow enamel*, by adding three ounces of tartar and seventy-two grains of magnesia; a *sea-green or beryl-colored enamel*, by adding three ounces of calcined brass and sixty grains of zaffre; and a *violet-colored enamel*, by adding two ounces of magnesia and forty-eight grains of calcined copper. These are the receipts given by Neri, approved by Kunkel, and now successfully used. The intensity and continuance of the heat must be attended to, as the colors both of enamels and of the transparent glasses imitating colored precious stones, especially of those which contain magnesia, depend much on these circumstances. White enamels may be composed of other substances besides calx of tin. Merret proposes to substitute regulus of antimony. Calcined bones, and perhaps other white earths, may be used for the same purpose. Mr. D'Arcet found that gypsum mixed with white clay, or with clay and hard spar, formed very beautiful enamels. Perhaps some of these enamels would form preferable glazings to that made with calx of tin, for covering those kinds of earthen ware which require, in the baking, greater heat than is suitable to the common enamel.

**CCLXIX. ESSAY.** Essays are chemical operations made in small, to determine the quantity of metal or other matter which is contained in minerals, or to discover the value or purity of any mass of gold or silver.

We shall treat successively of each kind of essay.

**CCLXX. ESSAY of ORES.** Before essays of ores can be well made, a preliminary knowledge of the nature of the several metallic minerals ought to be attained. Each metal has its proper and improper ores, which have peculiar characters and appearances: hence persons, accustomed to see them, know pretty nearly, by the appearance, weight, and other obvious qualities, what metal is contained in a mineral. A good essayer ought to be very intelligent in this matter, that he may at once know what the proper operations are which are requisite to the essay of any given mineral. Some remarks may be found on this subject under the article **ORES**.

As metals are very unequally distributed in their ores, we should be apt to make false and deceitful essays, if we did not use all possible precautions that the proportionable quantity of metal produced by any essay shall be nearly the medium contained in the whole ore. This is effected by taking pieces of the mineral from the several veins of the mine, if there be several, or from different places of the same vein. All these minerals are to be shook together with their matrixes. The whole is to be well mixed together, and a convenient quantity of this mixture is to be taken for the essay. This is called the *lotting* of the ore.

As essays, particularly the first, are generally made in small, essayers have very small weights corresponding to the weights used in the great, that is, to the quintal or hundred pounds weight, to pounds, ounces, drams, &c. The essay quintal and its subdivisions vary according to the difference of weights in different countries, and this occasions some confusion, when these weights are to be adjusted to each other. Tables of these weights are found in treatises of assaying, and particularly in that written by Schlutter, and translated and rendered more complete by Hellot, which contains all the details necessary for the subject.

The custom is to take, for the essay quintal, a real weight of a gros, or dram, which in France is equal to 72 grains; but as the whole dram represents 100 pounds, each grain represents a pound and a fraction of a pound; and hence some difficulty and confusion arise in making the subdivisions. A better method is that of Mr. Hellot, which is to make the fictitious or essay quintal equal to a hundred real grains, and then each grain represents a real pound. This essay quintal is sufficiently exact for ores of lead, tin, copper, iron, antimony, bismuth, and mercury. But for ores of silver and gold another representation is convenient; for these metals, as Mr. Hellot says, are generally in so small quantity, that the button or small piece of metal obtained in the essay could not be accurately weighed, if a hundred real grains were made to represent a quintal; and the difficulty of separating the gold from so small a quantity would be still greater. These motives have induced Mr. Hellot to use for these ores a fictitious quintal sixteen times bigger, that is, equal to 1600 real grains, which represent 1600 ounces, that is, 100 lb. or quintal. The ounce being represented by a grain, its several subdivisions must be represented by fractions of a grain.

Thus

Thus 12 grains of the fictitious quintal correspond with  $\frac{1}{4}$  of a real grain (*m*) ; and this latter quantity may be accurately weighed in essay ballances, which when well made, are sensible to a much less weight.

When a quintal of an ore to be essayed has been weighed, and lotted, as we described above, it is to be roasted in a test under a muffle. It is to be washed, if necessary ; and, in short, the same operations are to be made in small which are usually done in great. Additions also are to be made, and in proper proportions, according to the peculiar nature of the ore. The fluxes generally mixed with the ore in essays are three, four, or five parts of black flux ; one, two, or three parts of calcined borax ; and one half of that quantity of decrepitated common salt. The more refractory the ore is, the more necessary is the addition of these fluxes : then the whole mixture is to be fused either in a forge, or in a melting or essay furnace.

To make essays well, all possible attention and accuracy are to be employed. This object cannot be too much attended to ; for the least inaccuracy in weighing, or loss of the smallest quantity of matter, might cause errors, so much greater, as the disproportion betwixt the weights employed and those represented is greater. The most minute accuracy therefore is necessary in these operations. For instance, the essay ballances ought to be small, and exceedingly just. The ore ought not to be weighed till it has been reduced to gross powder fit for roasting ; because some of it is always lost in this pulverization. When the ore is roasted, it ought to be covered with an inverted test ; because most ores are apt to crackle and disperse, when first heated. To make the fusion good and compleat, the precise degree of fire which is requisite ought to be employed ; and when it is finished, the crucible ought to be struck two or three times with some instrument to facilitate the disengagement of the parts of the regulus from the scoria, and to occasion their descent and union into one button of metal. The crucible ought not to be broken, nor its contents examined till it is perfectly cold.

Upon breaking the crucible, we may know that the fusion has been good, if the scoria be neat, compact, and equal ; if it has not overflowed or penetrated the crucible ; if it contain no metallic grains ; and if its surface be smooth, and hollowed in the middle. The regulus or button ought to be well collected, without holes, or bubbles, and to have a neat convex surface ; it is then to be separated from the scoria, well scraped and cleaned ; and, lastly, is to be weighed. If the operation has been well made, its weight shows the quantity of metal which every real quintal of ore will yield in the great. If the perfect success of this essay be in any respect doubtful, it ought to be repeated ; but the best method at all times is to make several essays of the same ore. Some small differences are always found, however well the essays may have been made. By taking the medium of the results of the several operations, we may approach, as nearly as possible, the true product of the ore.

Lastly, as mines are not worked, nor founderies established (which cannot be done without considerable expence) till the ore has been essayed, ten or twelve

(*m*) The pounds, of which a hundred are here supposed to make a quintal, are called Paris pounds, one of which contains 9216 troy grains. See WEIGHT.

real pounds of the ore ought to be previously essayed; and essayers ought to be furnished with necessary furnaces and instruments for these larger essays.

We now proceed to give some examples of essays of ores. To essay a lead ore, for instance, which is not very refractory, let one or more quintals of this ore be grossly powdered, and roasted in a test till no more sulphureous vapors be exhaled, and then reduced to a finer powder; it is then to be accurately mixed with twice its weight of black flux, a fourth part of its weight of clean filings of iron and of borax. These proportions are given by Mr. Cramer. The mixture is to be put into a good crucible, or rather into a test; it is then to be covered with a thickness of two or three fingers of decrepitated sea-salt; the crucible is to be closed, and placed in a melting furnace, which is to be filled with unlighted charcoal, so that the top of the crucible shall be covered with it. Lighted coals are then to be thrown upon the unkindled charcoal, and the whole is left to kindle slowly, till the crucible be red-hot; soon after which a hissing noise proceeds from the crucible, which is occasioned by the reduction of the lead: the same degree of fire is to be maintained while this noise continues; and is afterwards to be suddenly encreased, so as to make a perfect fusion; in which state it is to be continued during a quarter of an hour; after which it is to be extinguished; and the operation is then finished.

The filings of iron are added to the mixture, to absorb the sulphur, a certain quantity of which generally remains united with the lead ore, notwithstanding the roasting. We need not fear lest this metal should unite with the lead and alter its purity; because although the sulphur should not hinder it, these two metals cannot be united. The refractory quality of the iron does not impede the fusion; for the union it forms with the sulphur renders it so fusible, that it becomes itself a kind of flux.

This addition of iron in the essay of lead ores would be useless, if the ores were sufficiently roasted, so that no sulphur should remain.

Lead ores generally contain some silver, and sometimes a considerable quantity of it; wherefore, after the ore has been essayed, and the regulus of lead collected and weighed, it ought to be tested, to discover the quantity of silver it contains; and as sometimes these lead ores contain also gold, the button of silver remaining upon the cupel ought to be essayed by parting, to ascertain the quantity of gold, if there be any.

The details for the essays of all other ores and minerals are too numerous to be inserted in this work. They are themselves the subject of several books, which may be consulted. The best of these books are Cramer's *Art of Essaying*, (*Ars Decimastica*), and Schlutter's Work translated into French by Mr. Hellot. We shall find many things relating to this matter under the articles, ORES, SMELTING OF ORES. (n)

(44) The essaying of ores is a matter of such importance to chemistry, to arts, and to the wealth of nations, that we shall endeavor to supply what the author of the Dictionary has omitted on this subject, by adding to the several articles of the ores of metals the methods of essaying these ores. See ORES. We shall here only observe in general, that

the methods generally practised for essaying ores of imperfect metals, and semimetals pecially, are insufficient to procure the whole quantity of metal contained in ores, or even so much as is obtained in the smelting of large quantities of ores; and that therefore the result of essays is not to be considered as the precise quantity contained in an ore, but generally

CCCLXXI. *ESSAY of the VALUE of SILVER*, to examine its purity, or the quantity of alloy mixed with it. The common method of examining the purity of silver, is by mixing it with a quantity of lead proportionable to the quantity of imperfect metals with which it is supposed to be alloyed; by testing this mixture; and afterwards by weighing the remaining button of silver. The loss of weight which the silver suffers by cupellation shews the quantity of imperfect metals which it contained.

We may hence perceive, that the essay of silver is nothing else than the refining of it by cupellation. The only difference betwixt these two operations is, that when silver is tested merely for the purpose of refining it, its value is generally known; and it is therefore mixed with the due proportion of lead, and tested without any necessity of attending to the loss of weight it sustains during the operation; whereas in the essay all possible methods ought to be employed to ascertain precisely this loss of weight. The first of these operations, or the more refining of silver, is made in the great, in the smelting of silver ores, and in mints for making money. See *REFINING*. The second operation is never made but in small; because the expences of small operations are less than of great, and the requisite accuracy is more easily attended to. The last operation is our present subject, and is to be performed in the following manner.

We suppose, first, that the mass or ingot of silver, of which an essay is to be made, consists of twelve parts perfectly equal, and these twelve parts are called penny-weights. Thus if the ingot of silver be an ounce weight, each of these twelve parts will be  $\frac{1}{12}$  of an ounce; or if it be a mark, each of these will be  $\frac{1}{12}$  of a mark, &c. Hence if the mass of silver be free from all alloy, it is called silver of twelve penny-weights; if it contains  $\frac{1}{12}$  of its weight of alloy, it is called silver of eleven penny-weights; if  $\frac{2}{12}$  of its weight be alloy, it is called silver of ten penny-weights; and these ten penny-weights or parts of pure silver are called *fine penny-weights*.

We ought to observe here concerning these penny-weights, that essayers give also the name *penny-weight* to a weight equal to twenty-four real grains; which latter real penny-weight must not be confounded with the former, which is only ideal and proportional; and such a confusion is the more likely to take place, as this

generally only as an inaccurate approximation to that quantity. Mr. Gellert ascribes one cause of the want of success of these operations to the alkaline salts employed as fluxes to the ores, by which most metallic calxes are partially soluble, but more especially so, when any of the sulphur of the ore remains; which, by uniting with these salts, forms a hepar of sulphur, which is the most powerful of all solvents. He proposes therefore to omit the black flux, and other alkaline salts, and to add nothing to the ore but powder of charcoal, and some fusible glass. This method, he says, he learned from Mr. Cramer, and has himself used with much success in the essays of iron and copper: but finding that other imperfect metallic sub-

stances could not sustain the heat necessary to effect the fusion and vitrification of the unmetallic parts of the ore without being partly dissipated, he found it necessary to add in the essays of these latter metallic matters some borax, by which the fusion might be completed with less heat. As we consider this as a considerable improvement in the art of assaying ores, we shall, to the articles of the several ores, add not only the processes commonly prescribed, but also these of Mr. Gellert, according to the method here mentioned. I have sometimes assayed ores very successfully by this method, from which I could obtain little, if any metal, by means of the black flux. See *ORES*.

ideal penny-weight is also, like the former, divided into twenty-four ideal grains, which are called *fine grains*.

An ingot of fine silver, or silver of twelve penny-weights, contains then 288 fine grains; if this ingot contains  $\frac{1}{8}$  part of alloy, it is said to be silver of eleven penny-weight and twenty-three grains; if it contains  $\frac{2}{8}$  of alloy, it is called silver of eleven penny-weight and twenty-two grains; if it contains  $\frac{3}{8}$ , it is called silver of eleven penny-weight and ten grains; and so on. Lastly, the fine grain has also its fractions, as  $\frac{1}{2}$ ,  $\frac{1}{4}$  of a grain, &c.

As essays to discover the value of silver are always made in small, essayers only take a small portion of an ingot for the trial, and the custom in France is to take thirty-six real grains for this purpose, which is consequently the largest weight they employ, and represents twelve fine penny-weights. This weight is subdivided into a sufficient number of other smaller weights, which also represent fractions of fine penny-weights and grains. Thus eighteen real grains, which is half of the quantity employed, represent six fine penny-weights; three real grains represent one fine penny-weight, or twenty-four fine grains; a real grain and a half represent twelve fine grains; and  $\frac{1}{4}$  part of a real grain represents  $\frac{1}{4}$  part of a fine grain, which is only  $\frac{1}{24}$  part of a mass of twelve penny-weights.

We may easily perceive that weights so small, and essay balances, ought to be exceedingly accurate. These balances are very small, suspended and inclosed in a box the sides of which are panes of glass, that they may be preserved from dust, and that their motion may not be affected by agitated air, so as to disorder their action.

When an essay of a mass or ingot of silver is to be made, the custom is to make a double essay. For this purpose, two fictitious semi-marks, each of which may be equal to thirty-six real grains, are to be cut from the ingot. These two portions of silver ought to be weighed very exactly; and they ought also to have been taken from opposite sides of the ingot.

Persons accustomed to trade operations know pretty nearly the value of silver merely by the look of the ingot, and still better by rubbing it on a touchstone. By the judgment they form of the purity of the ingot, they regulate the quantity of lead which is to be added to it, as this quantity must be always proportionable to the quantity of imperfect metal mixed with the silver.

Nevertheless, this proportion of lead to the alloy has not been precisely determined. Authors who treat of this subject differ much. They who direct the largest quantity of lead say, that thereby the alloy is more certainly destroyed; and others who direct a small quantity of lead pretend, that no more of that metal ought to be used than is absolutely necessary, because it carries off with it always some portion of silver. Every essayer uses his own particular method of proceeding, to which he is attached.

To ascertain these doubtful points, three chemists of the Academy of Sciences at Paris, Messrs. Hellot, Tuliet, and Macquer, were appointed by the French Government. They were directed to ascertain every thing concerning the essay of gold and of silver by authenticated experiments, made under the inspection of a minister whose superior knowledge is equal to his desire of public good, and in presence of the officers of the mint.

It appeared that the best proportions were, to add from two to three parts of lead to one part of silver of eleven penny-weights, and twenty-three grains value,

value, that is, which contains  $\frac{1}{11}$  of alloy; from four to six parts of lead to one part of silver of eleven penny-weight, twelve grains value, or which contains  $\frac{1}{11}$  of alloy, which is nearly the value of silver employed for plate; from six to eight parts to one part of silver of eleven penny-weight, which contains  $\frac{1}{11}$  of alloy, such as that of silver coin; and so on in proportion. (o)

Two cupels of equal size and weight are to be chosen. The custom is to use cupels of such a size that their weight shall be equal to that of one half of the lead employed in the essay; because such cupels have been found capable of imbibing all the litharge formed during the operation. These cupels are to be placed together under a muffle in an essay-furnace. The fire is to be kindled, and the cupels to be made red-hot, and to be kept so during half an hour at least before any metal be put into them. This precaution is necessary to dry and calcine them perfectly; because if they contained any moisture or inflammable matter, an ebullition and effervescence would be occasioned in the essay. When the cupels are heated so as to become almost white, the lead is to be put into them; the fire is to be increased, which is done by opening the door of the ash-hole so as to admit air, till the lead becomes red, smoking, and is agitated by a motion of its parts called its *circulation*, and till its surface becomes smooth and clear.

Then the silver previously beat into small plates, for its easier fusion, is to be put into the cupels; the fire is to be continued, and even increased, by putting hot coals at the mouth of the muffle, till the silver shall have *entered the lead*, that is, till it have melted and mixed with the lead. When the melted matter circulates well, the heat is to be diminished by taking away, partly or entirely, the coals put at the mouth of the muffle, and by closing more or less the doors of the furnace.

The heat ought to be regulated so, that the essays in the cupels shall have surfaces sensibly convex, and shall appear ardent, while the cupels are less red; that the smoke shall rise almost to the roof of the muffle; that undulations shall be made in all directions upon the surfaces of the essays, which are called *circulations*; that their middles shall be smooth and surrounded with a small circle of litharge, which is continually imbibed by the cupels.

The essays are to be kept in this state till the operation is finished, that is, till the lead and alloy have soaked into the cupel; and the surfaces of the buttons of silver being no longer covered with a pellicle of litharge, become

(o) The imperfect metals are destruible by scorification with lead; but when they are alloyed with silver or gold, a larger quantity of lead is required to produce the scorification of any given quantity of imperfect metals, than when they are not alloyed and defended from the action of the lead and fire by mixture with the perfect metals. And further, the quantity of lead requisite for this purpose must be increased, when the quantity of silver or gold, with which the given quantity of imperfect metal is alloyed, is increased. Thus, for instance, an ounce

of pure copper may be consumed by sixteen ounces of lead. But if an ounce of copper be alloyed with eight ounces of silver, about six times the above quantity of lead, or ninety-six ounces, will be required to destroy the ounce of copper; and if the ounce of copper be mixed with thirty-six times its weight of silver, its scorification will require 128 ounces of lead. The quantity of lead must be still further increased for another reason, namely, that almost all lead, as Cramer says, contains some portion of copper.

suddenly bright and shining, and are then said to *lighten*. If the operation has been well conducted, the two essays ought to become bright nearly at the same time. When the silver has been by this operation well refined, we may see, immediately after it has brightened, the surface of the silver covered with rainbow colors, which quickly undulate and cross each other, and then the buttons become fixed or solid.

The management of the fire is an important article in essays. For if the heat be too great, the lead is scorified and imbibed by the cupel so quickly, that it has not sufficient time to scorify and carry along with it all the alloy; and if the heat be too little, the litharge is gathered upon the surface, and does not penetrate the cupel. The essayers say then that the essay is *choaked* or *drowned*. In this case the essay does not advance, because the litharge covering the surface of the metal defends it from the contact of air, which is absolutely necessary for the calcination of metals. See CALCINATION and COMBUSTION.

We have above related the marks of a successful essay. The heat may be known to be too great, from the convexity of the surface of the melted metal; from a too strong circulation; from the too vivid appearance of the cupel, so that the colors given to it by the litharge cannot be distinguished; and lastly, by the smoke rising up to the roof of the muffle, or not being at all visible, from its being so ardent and red-hot as not to be distinguishable. In this case the heat must be diminished by shutting the door of the ash-hole: Some essayers, for this purpose, put round the cupels small, oblong, cold pieces of baked clay, which they call *instruments*.

If on the contrary, the melted metal have a surface not very spherical, relatively to its extent; if the cupel appear dark colored, and the smoke of the essay do only creep upon the surface; if the circulation be too weak, and the scoria which appears like bright drops have but a dull motion, and are not soaked into the cupel; we may be assured that the heat is too weak; much more may we be assured of it when the metal *fixes*, as the essayers call it. In this case, the fire ought to be increased by opening the door of the ash-hole, and by placing large burning coals at the mouth of the muffle, or even by laying them across upon the cupels.

As soon as the lead is put into the cupels, the fire is to be increased, because they are then cooled by the cold metal, and the lead ought to be quickly melted, to prevent its calx from collecting upon its surface in too great quantity before it be formed into litharge; which it would do, and be difficultly fused, if the heat were too weak.

When the silver is added to the lead, the heat must be still increased, not only because the silver cools the mass, but because it is less fusible than lead. And as all these effects ought to be produced as quickly as possible, more heat is at length given than ought to be continued; and therefore, when the silver has entered the lead, the heat is to be diminished till it becomes of a due intensity for the operation.

During the operation the heat ought gradually to be augmented to the end of it, both because the metallic mixture becomes less fusible as the quantity of lead diminishes, and also because the lead is more difficultly scorifiable, as it



is united with a larger proportion of silver. Hence the essays must be rendered very hot before they brighten.

When the operation is finished, the cupels are left in the same heat during some seconds, to give time to the last portions of litharge to be entirely absorbed; because if any of it remained under the buttons of silver, it would stick to them. The fire is then allowed to extinguish, and the cupels to cool gradually, till the buttons have entirely fixed, particularly if they be pretty large; because if they cool too quickly, their surfaces fix and contract before the internal mass, which is thereby so strongly compressed as to burst through the external solid coat and form vegetations, or even to be entirely detached from the rest of the mass and dissipated. This is called *the vegetation of the button*. It ought to be carefully prevented, because small bits of silver are sometimes thrown out of the cupel.

Lastly, when the buttons are thoroughly fixed, they are to be disengaged from the cupels by a small iron utensil while they are yet hot, otherwise they could not be disengaged clean and free from part of the cupels which strongly adhere to them when the heat is much diminished.

Nothing then remains to complete the essay but to weigh the buttons. The diminution of weight which they have sustained by cupellation will show the purity or value of the ingot of silver.

We ought to observe, that as almost all lead naturally contains silver, and that after cupellation this silver is mixed with the silver of the ingot in the button of the essay; before we employ any lead in this operation, we ought to know how much silver it contains, that we may subtract this quantity from the weight of the button, when we compute the fineness of the silver of the ingot essayed. For this purpose essayers generally cupel a certain quantity of their lead separately, and weigh accurately the button of silver it yields: or, at the same time when they essay silver, they put into a third cupel, in the muffle, a quantity of lead equal to that employed in both their essays; and when the operation is finished, and the buttons are to be weighed, they throw the small button produced from the lead alone into the scale which contains the weights; and as this exactly counterpoises the small portion of silver which the essay buttons have received from the lead employed in the cupellation, the weights will shew precisely the quantity of silver contained in the ingot, and thus the trouble of calculating is prevented. The small button of silver procured from the cupellation of lead alone is called the *witness*. But to prevent this trouble, essayers generally employ lead which contains no silver, such as that from Willach in Carinthia, which is therefore procured by essayers.

In the second place we shall observe, that a certain quantity of silver always passes into the cupel, as refiners in the great have long observed, and which happens also in essaying small quantities. The quantity of silver thus absorbed, varies according to the quantity of the lead employed, and the matter and form of the cupels; all which objects will undoubtedly be determined by the above-mentioned chemists.

The cupellation which we have now described is exactly the same for essays, by which the produce of a silver ore, or of an ore of another metal containing silver, is determined. But as these ores contain frequently gold, and sometimes

in considerable quantity, when these essays are made, the buttons of silver obtained by the essays ought to be subjected to the operation called *parting*. See SILVER, REFINING, FURNACE (ESSAY), MUFFLE, and CUPELL.

CCLXXII. ESSAY of the VALUE of GOLD. The fictitious weights used to determine the purity of gold, and to assay this metal, are different from those of silver. See the preceding article. A mass of gold perfectly pure, or which contains no alloy, is ideally divided into 24 parts, called *carats*; this pure gold is therefore called gold of 24 carats. If the mass or ingot contain  $\frac{1}{24}$  part of its weight of alloy, the gold is then of 23 carats; and if it contains  $\frac{2}{24}$  or  $\frac{1}{12}$  of alloy, it is gold of 22 carats, &c. Hence we see that the carat of gold is only a relative and proportional weight, so that the real weight of the carat varies according to the total weight of the mass of gold to be examined. If this mass of gold weighs a mark, the real weight of the carat will be  $\frac{1}{24}$  of eight ounces, which is equal to a mark. If the mass weigh an ounce, the carat will be  $\frac{1}{24}$  part of an ounce, or 24 grains. If it is only a penny-weight or 24 grains, the real weight of a carat will be one grain; and so on.

For greater accuracy, the carat of gold is divided into 32 parts, which are relative and proportional weights, as the carat itself is. Thus  $\frac{1}{32}$  of a carat of gold is  $\frac{1}{24}$  of  $\frac{1}{24}$ , or the  $\frac{1}{576}$  of any mass of gold; and the gold which contains an alloy equal to the  $\frac{1}{576}$  part of the whole mass is called gold of 23 carats and  $\frac{1}{32}$ ; gold which contains  $\frac{2}{576}$  of alloy is gold of 23 carats and  $\frac{1}{16}$ ; and so on.

The real weight now generally used in the operation for determining the purity of gold, is six grains. This weight then represents 24 carats. The half of this weight, or three real grains, represents 12 carats. According to this progression, we shall find that  $\frac{1}{4}$  of a real grain represents one carat, and the  $\frac{1}{16}$  parts of a grain represents the  $\frac{1}{32}$  of a carat, or the  $\frac{1}{576}$  part of a mass of gold to be assayed.

As these weights are exceedingly small, some assayers employ a weight of 12 grains, which must be very convenient.

When a mass or ingot of gold is to be assayed, six grains are to be cut off, and exactly weighed: also 18 grains of fine silver are to be weighed. These two metals are to be cupelled together with about ten times as much lead as the weight of the gold. This cupellation is conducted precisely like that of the assay to determine the purity of silver, excepting that the heat must be raised a little more towards the end of the operation when the assay is going to brighten. Then the gold is freed from all alloy but silver. If the quantity of copper or other alloy destructible by cupellation be required to be known, the remaining button is accurately weighed. The diminution of weight from the sum of the weights of the gold and of the silver determines the quantity of this alloy.

The button containing gold and silver is then to be flattened upon a polished piece of steel, and care must be taken to anneal it from time to time, to prevent its splitting and cracking. By this method it is reduced to a thin plate, which is to be rolled up, in order to be parted by aqua fortis. See the word PARTING. The diminution found after the parting from the original weight  
of

of the gold essayed, shews the whole quantity of alloy contained in that gold.

The essay for determining the purity of gold is then made by two operations : the first, which is cupellation, deprives it of all its imperfect metals ; and the second, which is parting, separates all the silver from it. By antimony also gold may be purified, which is a kind of dry parting. By this single operation, all the imperfect metals, and silver with which gold is allayed, are separated. See PURIFICATION of GOLD by ANTIMONY. See also GOLD, SILVER, REFINING, ESSAY to DETERMINE the PURITY of SILVER.

CCLXXIII. E S S E N C E S. Essential oils are sometimes called *essences*. Thus we say, essence of cinnamon, of turpentine, &c. to denote the essential oils of these substances. See OILS (ESSENTIAL).

CCLXXIV. E T H E R. Ether is a white, transparent liquor, of a peculiar and penetrating smell. Ether is very volatile : it may be entirely distilled without leaving any residuum, or suffering any decomposition or alteration. It is more volatile and inflammable than rectified spirit of wine. Its flame resembles the flame of spirit of wine ; but it is sensibly much greater, whiter, and more luminous. It is also accompanied with a slight smoke or foot, which spirit of wine is not.

Ether does not mix with water, as spirit of wine does, in all proportions ; but ten parts of water are required to dissolve one part of ether. This liquor has also a power of acting upon all oily and fat substances.

From these essential properties ether appears to be a substance exactly intermediate betwixt ardent spirits and oils, as has been proved in the elements of chemistry. See SPIRIT (ARDENT), and OIL.

Ether has been but lately known by chemists. From certain passages indeed of some old chemical books, we may infer that ether was not entirely unknown to their authors ; but they have not mentioned it distinctly, nor have they sufficiently described its properties, or the manner of making it : wherefore no attention was given to it, till the curiosity of chemists was excited by a publication in the Philosophical Transactions for the year 1730, by a German who calls himself Frobenius, (which however is supposed to be a feigned name) in which he relates the experiments he had made on that liquor, to which he first gave the name *ether*. Since that time, many chemists have made experiments on this matter. At first they made ether difficultly and in small quantities, and at length abundantly and easily ; particularly since Mr. Hellot communicated to several artists a process which he received from a foreign chemist. This process has been printed in the Encyclopedia, with consent of Mr. Hellot.

Since that time, Mr. Beaumé has operated more than any other chemist on ether. He has published the details of his experiments and researches, not only upon ether, but upon all the other substances produced from a combination of spirit of wine with vitriolic acid. This forms the completest treatise on this subject which has hitherto been published.

Vitriolic acid is not the only acid from the mixture of which with spirit of wine ether may be produced. The nitrous, marine, and acetous acids have also been found capable of forming, with spirit of wine, liquors possessed

of all the essential properties of ether; but differing from ether, properly so called, or vitriolic ether, by properties peculiar to each. We shall speak successively of these different ethers, beginning with the vitriolic, called simply *ether*, because it is the chief one and the first discovered. The following process for making this ether, which is the best hitherto published, is extracted from Mr. Beaumé's dissertation.

Put two pounds of perfectly rectified spirit of wine into a glass retort, and pour upon it at once two pounds of well concentrated vitriolic acid.

This acid being much heavier than the spirit of wine, sinks directly to the bottom, and does not mix with the spirit of wine. Shake the retort gently, and repeatedly, that the two liquors may mix. The mixture will boil, and become very hot. Vapors will issue from it with a loud hissing noise, and a sweet penetrating smell. The mixture will then assume a yellow-reddish color. Place the retort in a sand-bath, warmed by degrees to the same heat with itself. Lute to it a receiver, in the side of which is a small hole, and oblige the mixture by a heat sufficiently intense to make it quickly boil and to keep it boiling. At first a very sweet spirit of wine will pass into the receiver, after which the ether will come, which may be distinguished by stric formed on the upper part and neck of the retort. Continue the distillation with the same degree of fire, and from time to time unstop the small hole of the receiver, till you perceive, upon applying your nose near this small hole, a suffocating smell of volatile sulphureous acid. Then the receiver ought to be unluted; and the contained liquor, which will be nearly eighteen ounces, must be quickly poured into a glass bottle, which ought to be well stopped. This liquor is a mixture of a very dephlegmated part of the spirit of wine, of a sweet penetrating smell, which passes at first; of ether, which was formed during the distillation; of a little oil; and sometimes also of a small quantity of sulphureous acid; both which substances pass frequently with the last portions of the ether, particularly if the distillation has been too long continued. To separate the ether from these other substances, put the whole mixture into a glass retort, with a little deliquated fixed alkali, to absorb and retain the sulphureous acid, and distill very slowly in a sand-bath, with a very gentle lamp heat, till you have made one half of the liquor pass over. The liquor that rises in this distillation, called also *rectification*, is ether. (p)

Before the Count de Lauraguais had discovered that ether was miscible with water in a certain proportion, the custom was to put the ether after this distillation into a phial with distilled water, and to shake together these two liquors. The ether rose quickly to the surface, and floated on the water; from which it might be separated by a funnel, as oil may from water, and obtained unmixed. But this is evidently bad management: for in the first

(1) Mr. Beaumé says, that by distilling together six pounds of concentrated vitriolic acid with an equal quantity of highly rectified spirit of wine, about six ounces of aromatic spirit of wine will be first distilled, and then some ether. By continuing a heat sufficient to make the liquor boil, white vapors

of a volatile, sulphureous smell, together with some ether, will rise; and thus in 15 or 16 hours, about three pounds and a half of liquor will have passed into the receiver. If another receiver be adapted to the retort; by continuing the distillation, from ten to sixteen ounces of volatile sulphureous spirit will

place, the water thus mixed dissolves about one tenth part of its weight of ether before it is saturated, a which is lost ; and in the second place, for the same reason that water dissolves some ether, the ether also dissolves a certain quantity of water, by which it is weakened, and its properties altered, as Mr. Beaumé has observed.

The production of ether is one of the most beautiful and instructive phenomena of chemistry. Spirit of wine, which is at once inflammable, and miscible with water in all proportions, differs from any oil by containing a more considerable quantity of water, which enters its composition as a principle or constituent part. This being established, if we deprive spirit of wine of part of that aqueous principle by which it differs from oils, it ought to assume the characters of oil, and to approach so much more to an oily nature, as it has been deprived of a greater quantity of the watery principle which constitutes it spirit of wine and by which it differs from oil. But this is precisely what happens to it in the production of ether, and in the analysis of the remaining mixture after the formation of ether.

Concentrated vitriolic acid having a power of attracting water strongly, does, when mixed with spirit of wine, accordingly at first unite with the water which spirit of wine may contain superabundantly : and its action would not extend to the ether, and it would not separate the watery principle from the spirit of wine, if heat were not applied sufficient for distillation ; for ether cannot be obtained from this mixture but by distillation. But when by the distilling heat the power of the vitriolic acid to attract water is increased, that acid then becomes capable of separating the watery principle of the spirit of wine and of uniting with it.

What is done ; actually, so the spirit of wine which rises in distillation ought to be more and more changed by the action of the vitriolic acid.

will pass over, and from two to four gros\* of oil. By distilling the liquor in the first receiver, together with a small quantity of oil of tartar, by a very gentle heat of a lamp furnace, about two pounds and four ounces of pure ether may be obtained ; and afterward when a new receive is adapted, and a stronger heat applied, from eight to ten ounces of aromatic liquor, which makes a good anodyne mineral liquor of Hoffman, will be distilled. The ether which is first distilled is the purest, and that which passes afterwards has a smell of the oil of wine, improperly called sweet oil of vitriol, and of the volatile sulphureous acid. To obtain the largest possible quantity of ether, and free from the other liquors which are distilled in this operation, are the chief objects of attention : and, considering how much more

volatile ether is than any of the liquors which affect its purity, we have reason to believe, that a larger quantity, and a purer ether than is procured by the ordinary process, might be obtained by using an apparatus for the distillation and rectification, so contrived, that vents of different heights from the retort or matrass shall be given to the vapors of the different degrees of volatility, to each of which vents a receiver shall be adapted ; so that none but the purest ether can be found in the receiver communicating with the highest vent, and the ether which happens to be mixed with the other liquors in the receivers communicating with the inferior vents may be again rectified with less heat, till the whole quantity of pure ether be thus collected.

\* A gros is equal to 72 grains.

This accordingly happens; and very distinctly. The first liquor which rises in this distillation is a portion of spirit of wine, very volatile, penetrating, and dephlegmated; but which has not been deprived of its watery principle, and therefore retains the essential properties of spirit of wine.

The liquor which rises next is spirit of wine, deprived of part of its watery principle by vitriolic acid. It consequently is spirit of wine essentially altered, and approximated to the nature of oil, in proportion to the quantity of watery principle which it has lost. This is ether, which differs from spirit of wine in being no longer miscible with water in all proportions, and in emitting a whiter and more brilliant flame, accompanied with some fuliginous smoke.

These properties by which ether differs from spirit of wine characterize so well its oily nature, that most chemists consider this liquor as a very volatile oil. It seems, however, to be rather an intermediate substance betwixt oil and spirit of wine. The solubility of ether by water makes us chiefly consider it in this light; for what oil, properly so called, can be dissolved by water as ether can?

If the distillation of the mixture be continued after the ether has risen, the vitriolic acid, still continuing its action upon the spirit of wine already altered, takes at length from it all the watery principle by which it differs from a true oil, and hence ought to leave it in the state of oil. Accordingly, after the ether has passed over in distillation, an oil rises which wants none of the essential properties of true oil, as it is not miscible with water, burns with a fuliginous smoke, leaves a resinous coal, &c. This oil, thus created in some measure during the operation, is known by the name improperly given to it, of *Sweet Oil of Vitriol*.

From all this we might infer, that if ether ready prepared were mixed and distilled with concentrated vitriolic acid, it ought to be changed and transformed into sweet oil of vitriol. Accordingly Mr. Beaumé observed, that this did happen in an experiment he made, an account of which is given in his *Dissertation on Ether*.

When the sweet oil of vitriol is distilling, the vitriolic acid acts also upon the phlogiston of the remaining part of the spirit of wine, and unites with one part of the inflammable principle. Hence we may see at the same time much sulphureous, volatile, suffocating acid which forms it then becomes oil from the spirit of wine, this first spirit is penetrating, is very aqueous, and has not

By continuing this distillation, with a great quantity of this sulphureous acid is raised, which sometimes also a little concrete sulphur is found towards the end of the distillation, at a fixed supposition; for the same substances are

From all that has been said concerning the nature and properties of ether we may conclude, that this substance is nothing else than spirit of wine deprived by vitriolic acid of a part of its watery principle, and thereby approximated to the nature of oil. Some chemists believe that vitriolic acid is a constituent part

part of ether. This opinion, although it is not demonstrated, is not however destitute of probability, and deserves to be examined by experiments. For, on one side, a more copious and distinct acid is contained in all oils than in spirit of wine; and on the other side, the particular properties by which ethers formed by the nitrous, marine, and acetic acids differ from vitriolic ether, seem to be owing to adhering portions of the acids with which these ethers are prepared. This question requires a particular examination.

Ether is not employed in the arts, although it appears capable of being usefully employed in many cases, and particularly in the solution of certain concrete oily matters for the preparation of varnishes; but its high price prevents its introduction into the arts.

As ether is the most volatile and evaporable of all known liquors, and as in general liquors produce a degree of cold proportionable to the quickness of their evaporation, as Mr. Beaumé discovered, and several others have observed; therefore a very great degree of artificial cold may be produced by means of ether. Mr. Beaumé has sunk the mercury of Reaumur's thermometer to 40 degrees below the freezing point, by applying linens soaked in ether to the ball containing the mercury; and he makes this fine experiment every year in his course of chemistry conjointly with Mr. Macquer. (9)

Ether, like all thin and volatile oily matters, has the property of taking gold from aqua regia, but as it is more subtle than any other of these matters, it produces this effect better. For this purpose, ether ought to be poured upon a solution of gold in aqua regia, and the two liquors mixed together by shaking the containing phial. When this mixture is left to rest, the ether soon disengages itself from the aqua regia, and floats on the surface of the acid liquor, which being deprived of its gold is rendered white, while the ether has now acquired a yellow color from the gold it contains. This is an expeditious method of making a tincture of gold, or potable gold. We ought to observe that the gold which thus passes into the ether still retains a certain quantity of aqua regia.

Ether is employed in medicine. As a very thin and volatile inflammable matter, it acts powerfully on the nervous system, like all the matters of this kind. Frederic Hoffman was one of the first who employed it as a sedative and antispasmodic. The famous imperial anodyne liquor of this physician is nothing else than spirit of wine, in which are dissolved some ether and sweet oil of vitriol. It owes all its medicinal virtues to the ether.

Since ether has become more common and better known, many physicians prescribe it singly, in the dose of seven or eight drops upon a bit of sugar, which is to be eaten or to be dissolved in some proper liquor and drank. It is given in spasmodic colics, obstinate hiccups, convulsive, hysterical affections, and other disorders of this kind. It certainly produces frequently excellent effects; but, like all other antispasmodic remedies, it sometimes produces none.

(9) Mr. Amontons, in a Memoir of the Academy of Paris, (1699) and more particularly Mr. Richman, in a Memoir of the Academy of Petersburg, (1747) have observed that cold was produced by evapora-

ting fluids. Dr. Cullen discovered, that the cold thus produced by evaporating fluids was considerably greater in vacuo than in air. *See Essay Phys. & Liter. Edinburgh*, vol. 2, 1756.

Several persons have affirmed, that ether applied externally to the back of the neck, or to the temples, dissipated instantaneously, and as it were by enchantment, head-achs and meagrimis. I have tried it in all doses upon myself for these disorders, but without success; but we cannot from thence infer that it may not have better effects upon other persons. (\*)

**CCLXXV. ETHER (ACETOUS).** Since the discovery of the ether described in the preceding article, chemists have endeavoured to obtain such a liquor from spirit of wine by means of other acids, and accordingly they produced it first by means of the nitrous acid, then by the acetous, and lastly, by the marine. We shall speak successively of these several ethers.

The discovery of the production of ether by the acetous acid was made by the Count de Lauraguais. This ether is made by mixing together equal parts of rectified spirit of wine, and concentrated acid of vinegar obtained by distilling crystals of copper, called the Spirit of Venus, or radical vinegar. This mixture is to be distilled in the manner directed for vitriolic ether, and a considerable quantity of a liquor is obtained, which is possessed of the essential qualities of ether, as described in the former article, but which has also some of the acidity and peculiar smell of radical vinegar.

When this ether is mixed with liquid fixed alkali, and again distilled, or rectified by a lamp heat, an acetous ether is obtained free from superabundant acid, and much liker to true ether. It retains, however, the smell, not of the acid, but of the inflammable part of vinegar.

We observe, that by this process a greater quantity of ether is obtained than by distillation with vitriolic acid, which shews that the acid of vinegar is essentially fitter to produce ether than the vitriolic acid. This difference must undoubtedly be attributed to the great quantity of ardent spirit, which is one of the principles of the acid of vinegar, and which perhaps already approaches the state of ether. See VINEGAR (RADICAL).

As this discovery has been but lately made, the properties of the acetous ether, and the phenomena which its residuum may afford, have not yet been sufficiently examined.

**CCLXXVI. ETHER (MARINE).** The discovery of the true process for making ether by means of the marine acid, is the latest which has been made on this subject. The Marquis de Courtauvauz has communicated his process to the Academy of Sciences.

The difficulty with which marine acid unites in general with inflammable substances has retarded the discovery of marine ether; for no ether can be obtained by treating the most concentrated marine acid with spirit of wine in the ordinary method, by which the other ethers are produced. Able artists, and particularly Mr. Rouelle and Mr. Beaumé, had attempted unsuccessfully to procure ether by distilling smoking marine acid with spirit of wine. Mr. Beaumé, indeed, in his Dissertation concerning Ether, had given a process, by which he affirms that he had obtained a small quantity of marine ether. This

(\*) Ether dissolves all essential and expressed oils, animal empyreumatic oil, resins, and almost entirely ambergris. It dissolves difficultly petroleum and oil of amber. It precipitates argent of antimony from aqua regia, and silver from nitrous acid. It takes spots of grease from silks without affecting their colors.



process consists in making the fumes of the marine acid and of the spirit of wine meet together in the same receiver. But the quantity of ether obtained by this method was very small. The process also is troublesome, and even imperfect, as Mr. Beaumé himself declares. He would not have published it in that imperfect state, but because the possibility of the fact had been denied. What he says may be seen in his Dissertation on Ether.

Others, and particularly German chemists, had attempted to employ for this purpose a marine acid which was united with a metallic substance, such as the butter of antimony, and had observed the singular phenomena which happened in these mixtures. The Marquis de Courtanvaux has perfectly succeeded by employing the smoking spirit of Libavius, which is a highly concentrated marine acid, obtained from corrosive sublimate by tin, and impregnated with a considerable quantity of this metal.

This smoking liquor, mixed with an equal part of spirit of wine, and distilled together, easily produces a considerable quantity of a liquor possessed of all the essential properties of ether, and which may be considered as a true marine ether. The tin contained in the spirit of Libavius is separated and precipitated in form of a white powder. This ether, like the others, must be rectified to be obtained in its greatest purity. Some reflections concerning its nature will be found at the end of the following article.

**CCXXVII. ETHER (NITROUS).** This ether is obtained by mixing nitrous acid with spirit of wine, but with peculiar circumstances.

In the writings of ancient chemists traces of the nitrous as well as of the other ethers may be found; but these traces are neither clear nor precise. The first person who published a satisfactory account of this liquor, and who shewed the true method of obtaining it, was Mr. Navier, a Physician, at Chalons-sur-Marne, and Correspondent of the Academy of Sciences. His process, which he communicated to the Academy in 1742, is very simple, as it consists only in mixing together spirit of wine and spirit of nitre in a bottle, which is to be exactly closed, and left at rest, till the ether is formed and collected like an oil upon the surface of the liquor. This ether is made, as we see, without distillation.

Since Mr. Navier has published his discovery, other chemists have endeavored to improve the process. A very good process is published in the Encyclopedia, which is attributed to Mr. Rouelle. Mr. Beaumé also has published one in his Dissertation on Ether, which is very accurate, and is the result of many trials and researches. Mr. Beaumé's process is as follows.

Put six ounces of rectified spirit of wine into a bottle made of strong and thick glass, large enough to contain a pound of water. Place this bottle in a bucket of fresh water, which will be still better for the purpose if it has been rendered colder by throwing into it two or three pounds of ice, in small bits. Pour upon the spirit of wine, at four or five times, four ounces of smoking spirit of nitre, in concentrated, that a phial, capable of containing an ounce only of water, shall be capable of containing an ounce and a half of this spirit of nitre; observing, during the whole time of pouring the spirit of nitre, that the spirit of wine be kept in a state of perpetual rotation. As soon as the two liquors are mixed, stop the bottle quickly with a good cork, which must be driven firmly into the neck of the bottle, and covered

and.

and fastened with a piece of leather doubled, and bound with packthread. Leave it at rest in the cold water, which ought to be sometimes renewed.

Two or three hours afterwards, the liquor loses some of its transparency by the interposition of many small drops of ether, which are disengaged throughout the liquor. This ether gradually collects and floats upon the surface. Within twenty-four hours the mixture will have become clear; and the ether formed, which will be about two ounces, may be separated. But as more ether will still be produced, the method is to leave it seven or eight days before any of it be separated. After this time no more ether is formed. Pierce then the cork with a pointed instrument; and a considerable quantity of air will escape with a hissing noise, which had disengaged itself during the production of the ether, and which is compressed in the bottle. When the air has escaped, uncork the bottle, and pour quickly its contents into a glass funnel, that the ether may be separated.

The ether will amount to about four ounces, and the residuum will weigh five ounces and a half; so that half an ounce shall have been lost during the process. This ether ought to be put into a well closed crystal-glass bottle.

Nitrous ether in this state has a smell like that of the vitriolic ether, but somewhat stronger and less agreeable. It has a light citron color; and as soon as the bottle which contains it is uncorked, it bubbles and effervesces. When the stopper is put in loosely into the neck of the bottle, it may be observed to rise and fall alternately, which appearance is occasioned by vapors escaping from the ether. The cause of these phenomena is a considerable quantity of air which remains interposed betwixt the parts of ether; for when all this air has been once disengaged from the ether, these phenomena do not happen.

Nitrous ether is not, in this state, pure; as it contains some of the acid employed, from which it may be purified by mixing it with some fixed alkali, and rectifying it with a lamp-heat. In this rectification, it suffers a loss of nearly one half its quantity.

The properties of this rectified nitrous ether are, that it burns with a more luminous flame than the flame of vitriolic ether; that this flame is accompanied with a more sensible quantity of soot; that after the ether is burnt, a residuum of coal is perceptible; and, lastly, that if it be evaporated on the surface of water in open air, it leaves upon the water some oil, as the vitriolic ether does, but in a little larger quantity. In other respects, but in these which shew that the nitrous ether is of a more oily nature than the vitriolic, these two ethers are perfectly similar.

The activity and violence with which nitrous acid acts upon the spirit of wine is the most remarkable circumstance of this operation. The action of nitrous acid is so much stronger than that of vitriolic acid upon spirit of wine, that equal parts of concentrated nitrous acid and spirit of wine cannot be mixed and combined: for notwithstanding all the precautions that can be taken to moderate the action of these two liquors upon each other, they mix with so much violence when that proportion is used, that the mixture is instantly heated almost to inflammation, is reduced to vapors, and bursts the vessels with a terrible explosion.

In Mr. Beattie's Dissertation upon Ether, an account of the trials which he made upon this subject, and of the resulting phenomena, may be seen.

In the second place, when spirit of wine and nitrous acid are mixed in proper proportions, ether may be obtained without distillation; which is peculiar to this acid. The effects peculiar to the nitrous acid, in the preparation of ether, are caused by the action which this acid has, not only on the watery principle, but also on the inflammable principle of the spirit of wine. We have therefore reason to believe that nitrous acid converts spirit of wine into ether, not only by depriving it of its watery principle, but also by acting upon its inflammable principle with which it combines, or to which perhaps it joins its own inflammable principle. This is so true, that nitrous ether may be made with a nitrous acid which does not smoke, and which is, in some measure, saturated with water. For this purpose, a larger proportion of spirit of wine ought to be added. But if nitrous acid converted spirit of wine into ether, merely by depriving it of its watery principle, a diluted acid ought not to have the same effect as a smoking and concentrated acid, particularly as it cannot concentrate itself during the operation, since this is performed without distillation. Besides, as nitrous acid has a greater affinity than any other with the inflammable principle, and contains a greater quantity of it, we ought not to be surprised that nitrous ether is produced without distillation, and more easily than any other.

Marine acid, on the contrary, having the least disposition of all the acids to unite with the inflammable principle, and seeming to contain less of it than any other acid, does therefore produce ether with most difficulty; or, properly speaking, does not produce any ether, when pure, but only when it has been combined with metallic substances, as tin and antimony; part of the phlogiston of which it may have acquired. *See ETHER (MARINE)*. It probably becomes more proper to combine with the inflammable principle of the spirit of wine, or to communicate that which it has received, after it has already begun to unite itself with the inflammable principle of metallic matters.

From these considerations we are inclined to believe, that in the production of ether, the acids act at the same time upon the watery and inflammable principles of the spirit of wine, by depriving this spirit of the former, and by combining partly with the latter, or by increasing its proportion of acid, and thereby approximating it to an oily nature.

All acids, and particularly mineral acids, suffer singular alterations, and even transmutations, when they are distilled to dryness with a sufficient quantity of spirit of wine. Mr. POTT, in his *Dissertation on the Vinous Acid of Nitre*, says, that this acid by being combined with spirit of wine loses the disagreeable smell peculiar to it, and acquires a penetrating and agreeable smell; that it does not rise in form of red vapors; but that it rises with a less degree of heat than when pure, and that it acts less powerfully on fixed alkalis and absorbent earths. He adds, that by distilling this mixture, oil and a residuous coal may be obtained; and that if nitrous acid previously combined with spirit of wine be saturated with a fixed alkali, a salt is formed, which does not decompose like wine, but burns like an oily salt, without waste or diminution.

POTT reasonably thinks, that this experiment may suggest hints concerning the transmutation of acids, and he believes that the nitrous acid in that experiment

loses its detonating and other essential qualities; because the phlogiston which enters its composition as a principle is joined and confounded with the inflammable matter of the spirit of wine. The marine acid seems to suffer less alteration in combining with spirit of wine; for Mr. Pott says also, in his Dissertation on the Vinous Acid of Salt, that having saturated with an alkali some marine acid previously treated with spirit of wine, he obtained a regenerated common salt, which possessed all the essential properties of common salt. Nevertheless, Mr. Pott, having distilled to dryness the thick matter which remains after the most fluid and volatile part had been distilled from a mixture of marine acid and spirit of wine, obtained a residuous black fixed coal; which proves that one part of the acid of salt contracts in this experiment a very intimate union with the principles of spirit of wine; for the marine acid and spirit of wine distilled singly do certainly not leave any residuum.

CCLXXVIII. ETHIOPS (MARTIAL). Martial ethiops is iron divided into exceedingly fine parts by the action of water.

This preparation was introduced into medicine by the younger Lemer, who called it *ethiops* from its black color. To make ethiops, filings of iron are taken, very clean and free from rust, and are put into a glass vessel; on these pure water is to be poured, to the height of three or four fingers thickness above the filings; the filings are to be frequently stirred with a spatula, till they become so fine a powder, that when agitated they remain long suspended in the water: the water thus rendered turbid by the suspended powder of iron, is to be decanted; and the sediment which is deposited is to be dried and ground on a porphyry. This is the martial ethiops.

Iron is a metal which is soluble in many menstrua. Its surface is sensibly affected by the combined action of air and water, and is in some measure corroded. It is thereby deprived of part of its inflammable principle, and partly reduced to an earth or calx, called *rust*; but to produce this effect, these two elements must concur; for iron is not rusted nor altered by exposure to dry air, or to water alone, without contact of air. (1)

Nevertheless, the operation of ethiops martial shows that water alone, without the concurrence of air, is capable of a certain action upon iron; since this metal is by this action, continued some time, reduced to parts exceedingly small. Whether this effect is caused by some heterogeneous particles in the water or in the iron, has not yet been determined. The iron thus reduced into martial ethiops is certainly very different from rust. It is black, attractive by magnets, and soluble in all acids; which proves that it is not deprived of its inflammable principle. Rust, on the contrary, has none of these qualities.

These properties of martial ethiops have induced some persons to propose it as a remedy much superior to other preparations of iron. The manner of preparing iron for medicinal purposes is certainly good and unexceptionable; but

(1) Iron is not so readily rusted when kept immersed in water, as when it is first moistened and then exposed to air; but it is nevertheless subject to rust if it be kept a few days under water, as those workmen know who have occasion frequently to keep pieces of iron under water, to soften and render the metal more ductile, and also to preserve the surface from rust during a short time. When they have occasion to preserve iron from rust a longer time, they immerse it in lime-water.

Mr.

Mr. Lemerî certainly ought not to have declaimed against all other preparations of iron indiscriminately, nor to have advised their total disuse in medicine. He pronounced this general proscription without sufficiently understanding the matter. He would probably have been more indulgent, if he had known that several martial saffrons, such as those called aperitive, and which are nothing but rust, are capable of easily returning, and by the humid way all the phlogiston which is necessary to restore to them all the properties of martial ethiops; and that this change is actually produced upon them when they are taken internally, by the fat matters which they meet in the stomach, in the intestines, and in the aliments and digestive juices. This is proved by the blackness of the excrements of those who have taken these martial saffrons.

Mr. Lemerî had certainly not examined the nature of the precipitates obtained from solutions of iron in acids, and particularly in the vitriolic and marine acids, by a phlogisticated alkali; for he must have observed that such precipitates receive from the alkali a sufficient quantity of phlogiston, to give it a dark and blackish color, and to render it soluble in any acid: consequently these precipitates, which are at least as fine as the martial ethiops, are also equal to it in solubility, and preferable from the greater facility of their preparation.

When well phlogisticated precipitates are required, they ought to be dried in close vessels, and by distillation. This is an operation which is also necessary for martial ethiops, although the author does not direct it; for the iron, being moist and much divided, rusts with the greatest facility from the contact of air.

Martial ethiops, and the martial precipitates and saffrons above-mentioned, are successfully employed in medicine as excellent tonic and fortifying remedies.

*See upon this subject Iron.*

**CCLXXIX. ETHIOPS MINERAL.** Ethiops mineral is a combination of mercury with a sufficiently large quantity of sulphur. The color of this compound is black, and hence it has been named ethiops.

Ethiops mineral may be made either by fusion, or by trituration without fusion.

**To make ethiops mineral by fusion:** To sulphur melted in an unvarnished earthen vessel, an equal quantity of very pure mercury is to be added; the vessel is at the same time to be taken from the fire, and the mixture is to be stirred with a spatula till it becomes hard and fixed; the mixture is then become a black and friable mass, which is to be pounded and sifted. This is ethiops.

**To make this preparation without fire:** two parts of mercury are triturated in a glass or marble mortar with three parts of flowers of sulphur, till the mercury no longer appears.

Mercury and sulphur have a strong disposition to unite together. For this purpose, their intermediate parts must be made to touch, and then they contract an adhesion, but not so strong as that which they acquire by sublimation in the process for making cinnabar.

The black color of ethiops is always taken by mercury, when it is much divided and mixed with inflammable matters. In this respect it resembles silver, lead, and other metals, which acquire a black color from the superficial union which they contract with sulphur or other phlogistic matters.

Although the union of mercury with sulphur in ethiops is not so strong as in cinnabar, we must not believe that in ethiops these two substances are not united,



but only mixed and interposed; for they really adhere and are combined together. The proof of this is, that they cannot be separated from each other without intermediate substances. These substances are the same as those which are capable of procuring a similar separation by decomposing cinnabar. *See CINNABAR.*

The difference betwixt ethiops prepared by fusion and ethiops prepared by trituration is, that the former contains a less quantity of sulphur than the latter.

Mr. Lemeris has observed, in his *Course of Chemistry*, that when ethiops is made with fire, one half of the substances employed is lost; but the proportion in which each of the substances is dissipated is not known; we are, however, certain that more sulphur is lost than mercury; notwithstanding which, each kind of ethiops contains more sulphur than is necessary for the saturation of the mercury, as evidently appears from the operation of making artificial cinnabar.

The chief use of ethiops mineral is in medicine. It may be given from six grains to half a dram, incorporated with other suitable remedies. It is employed as a resolvent in the asthma, scrophula, obstructions and diseases proceeding from a stoppage or thickness of humors. Some physicians prescribe it in venereal diseases: others affirm, that ethiops has no medicinal virtue; however, it certainly occasions salivation sometimes, although seldom. *See MERCURY.*

**CCLXXX. EVAPORATION.** Evaporation is a chemical operation, by which, with a certain degree of heat and access of air, volatile substances are separated from others less volatile.

The effect of evaporation is essentially the same as that of distillation, with this difference, that distillation is almost always employed to separate and collect a volatile substance; whereas evaporation is always employed to separate and collect the fixed or less volatile substance only, the more volatile part being necessarily lost in the operation.

Evaporation is always made in open air, and in open vessels; for air contributes much to the volatilization of bodies, and evaporation is only performed from their surfaces; hence the general rules for evaporation are, to place the body from which volatile parts are to be evaporated in a flat, shallow, wide vessel, so that it shall present to the air a large surface, towards which even a current of air ought to be directed.

In all evaporations the degree of heat ought to be proportioned to the volatility of the substance to be evaporated, and still more to the degree of fixity of the substance intended to be left, and of its adhesion to the volatile parts. Thus, the less fixed the remaining substance is, and the more strongly it adheres to the volatile substance, the less the heat ought to be. For instance, if we would obtain the portion of oil which is found in a certain kind of wine and ether, these liquors ought to be evaporated in a flat vessel, and upon the surface of water in open air, and without any other heat than that of the atmosphere; for, however little the evaporation of these liquors is assisted by a heat somewhat too strong, the volatility of this small portion of oil differs so little from that of spirit of wine and of ether, that it would scarcely separate with these liquors without any separation, as it does when they are rectified. Thus Mr. Bohnet having discovered, by his experiments, that the volatile oil of fat ammoniac

comes

carries off with it a considerable portion of the fixed earthy intermediate substances employed to disengage it, could not afterwards separate this earthy part from the concrete volatile alkali, but by allowing this latter to dissipate itself by the heat alone of the air, and by an evaporation which continued several months; because this earthy part, although very fixed, is so well combined, and adheres so strongly to volatile alkali, that it is always carried along with the salt in evaporation, whenever the heat exceeds that of the atmosphere. See Mr. Dubamel's *Memoirs concerning Sal Ammoniac* amongst the *Memoirs of the Academy*.

On the contrary, in some cases evaporation may be urged by a strong heat, and even by a current of air directed upon the surface of the body. This is practised when the part to be evaporated is not very volatile, and requires considerable heat to raise it, and when the remaining substance is very fixed, and does not adhere much to the volatile part. Such, for example, is the evaporation of regulus of antimony in the purification of gold by antimony. See that operation.

The vessels employed in evaporation are basins, tests, crucibles; and these vessels are made of glass, metal, or of earth, according to the nature of the bodies on which the operation is to be performed.

#### CCLXXXI. EUPHORBIIUM.

#### CCLXXXII. EXCREMENTS (LIQUID) of ANIMALS.

See URINE.

#### CCLXXXIII. EXCREMENTS (SOLID) of ANIMALS.

Alchemists who have dugas every where for their great work, as they called it, have particularly operated much on the excrements of men and other animals; but philosophical chemistry has acquired no knowledge from all these alchemical labors, from the obscurity with which their authors have described them. The philosophic chemists have not much examined animal excrements. Of these, Homberg is the only one who has particularly analysed and examined human ordure; and this was done to satisfy an alchemical project of one of his friends, who pretended that from this matter a white oil could be obtained, without smell, and capable of fixing mercury into silver. The oil was found by Homberg, but mercury was not fixed by it.

The labors of this able chemist were not however useless, like those of the alchemists, because he has clearly related the experiments he made on this matter, in the *Memoirs of the Academy of Sciences*. These experiments are curious, and teach several essential things concerning the nature of excrements. The result of these experiments is as follows.

Fresh human stools, being distilled in dryness in a water bath, furnish a clear, watery, insipid liquor, of a disagreeable smell, but which contains no volatile alkali, which is a proof that this matter, although nearly in a putrefactive state, is not however putrefied; for all substances really putrid furnish with this degree of heat a manifest volatile alkali. See PUTREFACTION.

(a) Euphorbia is a very acrid, resinous juice. From an ounce of euphorbia five drams were extracted by water, and from another ounce five drams were extracted by water. Both these extracts, but chiefly the spirituous, were acrid and corrosive. *Avicenna*.

The dry residuum of the foregoing experiment, being distilled in a retort with a graduated fire furnishes volatile alkaline spirit and salt, a fixed oil, and leaves a residuous coal. These are the same substances which are obtained from all animal matters. *See SUBSTANCES (ANIMAL)*.

Human feces, diluted and lixiviated in water, furnish by filtration and evaporation of the water an oily salt of nitrous nature, which deflagrates like nitre upon ardent coals, and which inflames in close vessels, when heated to a certain degree.

This same matter yielded to Homburg, who treated it by a compleat fermentation or putrefaction, excised by a digestion during forty days in a gentle water-bath heat, and who afterwards distilled it, an oil without color, and without bad smell, and such as he endeavored to find, but which did not, as we said before, fix mercury into silver.

**CCLXXXIV. EXPRESSION.** Expression is a mechanical operation, by which the juices of many plants are obtained; and sweet oils, which are not volatile, may be extracted from many substances in which they reside superabundantly and uncombined. Such are all emulsive seeds, and some fruits, as oranges, citrons, lemons, olives, &c. An oil may also be obtained from yolks of eggs by expression.

This operation is performed by putting the substance to be expressed, previously bruised, in a machine called a press.

The plants from which the juices are to be extracted, having been bruised in a mortar, ought to be wrapped up in a strong and closely woven linen cloth, and then put into the press. The plants which are not very succulent, or too mucilaginous to give their juices by expression, ought to be mixed with some water when they are bruised in a mortar.

Grains or seeds must also be bruised before they are expressed to obtain their oil, so as to form them into a greasy paste, the oil of which exudes spontaneously. They are then to be wrapped in a strong linen cloth, and expressed. To obtain as much oil as is possible, this paste ought to be expressed betwixt two hot iron plates. But this method renders oils rancid, and therefore ought not to be used in the preparation of oils for medicinal purposes.

To obtain oil from yolks of eggs by expression, they ought previously to be hardened by baking, or even a slight roasting. *See JUICES (EXPRESSED), and OILS (SWEET)*.

**CCLXXXV. EXTRACT.** This word, taken in the most general sense of which it is capable, is applicable to substances separated from any compound body by a proper menstruum. But it is generally confined to denote substances separated from vegetables by water.

To make an extract from any vegetable substance, it must be infused or boiled in a sufficient quantity of water to extract from it all the substances soluble in this menstruum. If the vegetable matter of which the extract is to be made is itself succulent and watery, it need not first be bruised or boiled. The juice which contains all the matter of the extract may be expressed; for in this case, the water in the plant has the same effect as the water employed in infusion or decoction.

Then



Then the infusion, decoction, or expressed juice of the plant must be evaporated till they acquire more or less firm consistence. For some extracts are made as soft as paste, and are called *soft extracts*; others are evaporated till they become dry, and are called *dry* or *solid extracts*.

The liquor from which the extract is to be made by evaporation is always more or less charged with feculent matters, earthy or resinous, which render it turbid, because these matters are not soluble in water. These matters are generally separated before the liquor is evaporated to the consistence of an extract, which may be done by clarification with the white of an egg, or otherwise. By this separation of feculent matter, soft extracts are rendered less liable to ferment and to become mouldy. But as the intention of making an extract is to preserve all that can be preserved of the principles of plants, the liquor of the extract ought not to be clarified, but it ought to be evaporated till it becomes dry, and thereby rendered not subject to change.

As extracts ought to resemble as nearly as is possible, the vegetables from which they are obtained, they ought to be evaporated with a gentle heat, and in a water-bath; because the delicate and compounded principles of vegetables are liable to be changed by a strong heat. But to avoid the inconveniences attending a tedious evaporation, by which a fermentation of the matter might be induced, this evaporation may be accelerated by increasing the surface of the liquor, which therefore ought to be distributed in many flat and wide-mouthed vessels. See *Evaporation*. In this manner the Count de la Garaye prepared what he called *essential salts*, which are nothing but solid extracts, the best and most perfect which can be obtained.

From what has been said concerning extracts, we may conclude, that they are collections of the proximate principles of vegetables, and chiefly of those which are soluble in water, and which are not so volatile as to be capable of dissipation by the heat of boiling water. They contain, therefore, when well made, all the gummy, mucilaginous, saponaceous, (that is, the oil rendered soluble in water by some saline substance) bitter, or saccharine matters; and lastly, all the essential salts, acids or others, or any other saline matters, which are contained in vegetables. In well-made extracts are also found portions of the oily, resinous, and earthy principles of vegetables, which, although insoluble in water, have been extracted along with the other principles into the juice, infusion, or decoction; excepting, for particular reasons, these principles are required to be excluded. If extracts are required which shall possess as much as they can, of the properties and virtues of plants, we ought not only to extract by water but also by spirit of wine, and to mix together the substances thus extracted by these two menstrua. See *ANALYSIS by MENSTRUUMS*.

The taste of almost all extracts is bitter or saline, and somewhat like that which sugar or other vegetable substances acquire by slight burning. But this latter quality is faulty. It proceeds from a too strong heat having been employed to evaporate the extracts, by which some of the substances contained in the extract are considerably changed or even destroyed.

Several

Several dry extracts, or essential salts of the Count de la Garaye, attract moisture from the air, and even become liquid. This property is occasioned by a separation of the saline from the resinous and earthy parts of the vegetable, and which are therefore uncombined, and consequently apt to attract moisture.

These extracts ought to be preserved in well closed bottles.

CCLXXXVI. EXTRACT (MARTIAL). This name is given to a pharmaceutical preparation, which is not, properly speaking, an extract, since it is only a combination of iron with tartar, called *Tincture of Mars*, reduced to the consistence of an extract. See TINCTURE of MARS.

## F.

CCLXXXVII. **F A L S E G A L E N A.** This is a mineral which resembles at first view the lead ore called galena; but from which no metal is extracted. (u)

CCLXXXVIII. **F A L S E P R E C I P I T A T E.** This name is given to a matter which has the appearance of a precipitate, but which has not been separated from a menstruum. Such is mercury reduced into a red powder without addition, and merely by heat, improperly called *precipitate per se*, or mercury precipitated by itself: such also is *red precipitate*, which is mercury dissolved in spirit of nitre, and afterwards deprived of most of the acid by fire, without any intermediate substance. Silver, lead, mercury, separated from nitrous acid by marine or vitriolic acids or salts, are also generally considered as precipitates, and are really so, as they are actually separated from one substance by the intervention of another: but, as this separation is made by the union of the precipitated metal with the precipitating acid, such precipitate ought to be distinguished from those which are nothing but the precipitated matter uncombined and single. See **P R E C I P I T A T E S** and **P R E C I P I T A T I O N**.

CCLXXXIX. **F A T.** Fat is an oily concrete substance, deposited in different parts of animal bodies.

To obtain fat very pure, it must be cut into pieces, and cleaned from the interposed membranes and vessels; it must then be cleansed from its gelatinous matter by washing with water, till the water comes from it colorless and insipid; it is afterwards to be melted with a moderate heat, in a proper vessel, with a

(u) **F A L S E G A L E N A.** *False Galena*, called also *Black-jack*, or *Blind*, is an ore of zinc, containing, besides that metal, generally some iron, together with the mineralizing substances, sulphur and arsenic. It is frequently intermixed with the lead ore called galena, and sometimes with the precious pyrites. In England this formation is found in the lead mines of Derbyshire, and the latter in the copper mines of Cornwall. This mineral, formerly neglected as useless, has lately been employed, after a careful calcination, instead of calamine, for the manu-

facture of brass, and might also be employed as calamine is, for the extraction of zinc. For these purposes, that kind of blend is chosen which contains most zinc, and least of iron and arsenic. Such is the blend of Derbyshire, which is a very rich ore of zinc. This kind is more laminated in its texture, and of a greyish color when scratched; whereas the blend found in Cornwall has a more tessellated texture, consisting of oblong parallelograms, is of a reddish color when scratched, and contains a larger quantity of iron and arsenic.

little water; and it is to be kept thus melted till the water be entirely evaporated, which is known by the discontinuance of the boiling, which is caused by the water only, and which lasts till not a drop of it remains: it is afterwards to be put into a ~~air-bath~~ <sup>glass</sup> ~~pot~~, where it freezes; then it is exceedingly white, sufficiently pure for the purposes of pharmacy or chemical examination.

Fat thus purified has very little taste, and a weak, but peculiar smell.

Mineral acids exhibit the same phenomena with fat, as they do with the fixed sweet oils of vegetables, which contain nothing gummy or resinous, and which do not dry. Such is the oil of ben, oil of olives, and all those which chemists call *fat oils*.

Alkalis dissolve fat, as they do these oils, and form a similar soap. Fat contains no principle so volatile as to be raised with the heat of boiling water. It does not inflame but when heated in open air so as to rise in vapors. Lastly, by age it contracts an acrid and rancid quality.

When fat is distilled with a heat superior to that of boiling water, which must therefore be done in a retort, and in a naked fire, first an acid phlegm arises, and a small portion of oil which remains fluid. As the distillation continues, the acid becomes stronger, and the oil thicker, and at last it congeals in the receiver. No other principle arises during this distillation: and lastly, when the retort is red, nothing remains but a very small quantity of that kind of coal which cannot be burnt without very great difficulty. See COAL.

If the congealed oil which is found in the receiver be again distilled, more acid is obtained, and an oil which does not congeal; and thus by repeating the distillations the oil is more and more attenuated. While it is thus deprived of its acid, it acquires a more and more penetrating smell; and thus by distillation alone it may be rendered as volatile as essential oils, and capable of rising with the heat of boiling water.

From all these properties of fat we may perceive it is a sweet concrete oil, not volatile, and perfectly analogous to butter and wax; and that its consistency, as well as the consistence of these analogous substances, is caused by an acid intimately united with it, which cannot be separated but gradually and by repeated distillations. Fat, and all other analogous oils, cannot be heated sufficiently to be raised into vapors, without suffering a considerable alteration, and even decomposition. The vapors which rise from it when heated in open air, are the same as those which rise when distilled in close vessels. They consist of acid and attenuated oil. This acid is remarkably penetrating, acrid, and volatile; it inflames and irritates the eyes, the throat, and lungs; it makes the eyes fixed tears, and causes a cough as much as volatile sulphureous acid does, although its nature be very different.

When fat is in its natural state, and has not yet suffered any alteration, its acid is so well combined with its oil part, that none of its properties can be perceived. Thus fat, in good condition, is very mild, and is successfully in medicine, particularly externally, for its solvent quality; but, notwithstanding its great mildness, before it has been heated sufficiently to decompose it, and while it is yet fresh, it becomes exceedingly acrid, irritating, and caustic, when its acid is partly disengaged by fire or by time.

When fat is become very rancid, not only its medicinal effects, but also many of its essential properties, are totally changed, particularly its property of resisting

resisting the action of spirit of wine: for this menstruum, which does not affect pure and unchanged fat, dissolves some portion of fat which has been strongly heated, or which has become rancid. This effect can certainly proceed from no other cause, than that the acid of the fat disengages itself in both these cases. Mr. Macquer has shewn this in his *Memoir* concerning the Cause of the different Solubility of Oils in Spirit of Wine. We shall speak more fully on this matter at the article OIL. Mr De Machy, an intelligent apothecary of Paris, and an able chemist and observer, has made a remark upon this subject which corresponds with this opinion; which is, that all the rancidity of fat may be taken from it by treating it with spirit of wine. Now, this evidently happens, because the spirit of wine dissolves all the portion of fat which is disengaged from its acid; that is, all the rancid part, while it does not touch that which is not changed. This practice may be advantageously employed for the preservation or recovery of some fats used in medicine, but which are rare, and not to be procured in their recent state.

The decomposition of fat, from which may be obtained acid, oil, a very small quantity of residuous coal, and not a particle of volatile alkali, proves evidently, that this substance, although elaborated in animal bodies, of which it makes a part, has not the marks of an animalised matter; it therefore seems to make a separate class, and to be produced from the oily parts of the aliments which could not enter into the composition of the nutritive juices: it is consequently an oil superabundant to nutrition, which nature deposits and reserves for particular purposes. One of the chief uses of fat probably is to receive into its composition, to blunt and correct a great part of the acids of the aliments, and which are more than are requisite to the composition of the nutritive juice, or which nature could not otherwise expel. This is certain, that the greater the quantity of aliments is taken by healthy animals above what is necessary for their nourishment and reproduction, the fatter they become. Hence animals which are castrated, which are not much exercised, or which are come to an age when the loss and production of the seminal fluid is less; and which, at the same time, consume much succulent aliment, generally become fatter, and sometimes exceedingly so.

Although fat be very different from truly animalised substances, and appears not easily convertible into nutritive juices, it being generally difficult of digestion, and apt to become rancid, as butter does in the stomachs of many persons; yet in certain cases it serves to the nourishment and reparation of the body. Animals certainly become lean, and live upon their fat, when they have too little food, and when they have diseases which prevent digestion and production of the nutritive juice; and in these cases the fatter animals hold out longer than the leaner. The fat appears to be then absorbed by the vessels designed for this use, and to be transformed into nutritive juice.

The fats of different animals differ little. They have all the same essential properties, and only vary sensibly in consistence. Frugivorous animals, and particularly sheep, have very firm fat; most reptiles, and particularly fish, which are almost all carnivorous, have a soft and sometimes a liquid fat. See BUTTER, WAX, and OIL.

CCXC. FEATHERS. (\*)

CCXCI. FENNEL. (y)

CCXCII. FRUGREEK. (z)

CCXCIII. FERMENT. A ferment is a substance actually fermenting, or strongly disposed to ferment, and which is employed to determine and excite another body to fermentation; such are yeast, leaven, and other such substances. See FERMENTATION.

CCXCIV. FERMENTATION. Fermentation is an intestine motion, excited spontaneously, with the assistance of proper heat and fluidity, betwixt the integrant and constituent parts of certain very compound bodies, from which result new combinations of the principles of these bodies.

All vegetable and animal matters, into the composition of which enter a certain quantity of fluid oil and earth, rendered perfectly soluble in water by the intervention of a saline matter, being diffused in a sufficient quantity of water to become liquid, or at least soft, and being exposed to heat from a few degrees above the freezing point to twenty-five and more, and when the communication with air is not entirely stoppt, suffer spontaneously the fermentative motion, which entirely changes the nature and proportion of their principles.

But this fermentation, and the new compounds produced by it, differ considerably both in properties and proportions, according to the nature of the fermented substance, and the circumstances of the fermentation.

We may distinguish three particular kinds of fermentation, or three degrees of the same fermentation, which refer to the three principal products which result from it.

The first is called *vinous* or *spirituous fermentation*, because it changes into wine the liquors which undergo it, and because from this wine may be obtained an inflammable spirit, miscible with water, called *spirit of wine*.

The second kind of fermentation is called *acid* or *acetous*, because the product of it is an acid, or *vinegar*.

The third fermentation is called the *putrid* or *putrefaction*. It might also be called the *alkaline* fermentation, because much alkali is disengaged by it.

All matters susceptible of the spirituous fermentation may afterwards undergo the acid, and, lastly, the putrid fermentation; but some substances are not susceptible of the spirituous fermentation, but proceed first to the acid, and afterwards to the alkaline or putrid fermentation; and lastly, some substances are susceptible of the putrid fermentation only. Further, a substance which

(\*) FEATHERS. From sixteen ounces of feathers Neuman obtained six ounces, two drams of spirit, two ounces and two drams of salt, one ounce two drams of oil, and a residuum, from which, after calcination, twenty-six grains of saline matter were elixated.

(y) FENNEL. The leaves and seeds of common fennel contain an essential oil. The oil obtained from the leaves on the upper part of the plant is much finer, lighter, and

more subtle than the oil obtained from the lower leaves. The former oil swims on water, and the latter oil sinks. Neuman.

(z) FRUGREEK. The seeds of this plant contain an essential oil blended with resin and mucilage, but no essential oil. From sixteen ounces, eleven drams were extracted by water; and from the same quantity, four drams and a half were extracted by spirit of wine. Neuman.

having

having undergone the spirituous fermentation, has proceeded to the acid fermentation, cannot be again made to undergo the spirituous, but passes necessarily to the putrid. Also those substances which have undergone the acid fermentation directly, that is, without previously passing through the spirituous, are only then susceptible of the putrid, and not of the spirituous fermentation; and the substances which pass directly to the putrefactive fermentation cannot be made to undergo, at least sensibly, the acid, and still less the spirituous fermentation. Lastly, any matter susceptible of the spirituous fermentation cannot be made to putrify without previously passing through the spirituous and acid fermentations.

These considerations have induced most chemists, and particularly the great Stahl, to consider these fermentations less as three operations distinct and independent of each other, than as three principal and distinguished degrees of one and the same fermentative motion, by which nature endeavors to resolve, and to reduce into a similar condition, all the most compounded bodies, into the combination of which enters the oily principle; that is, all animal and vegetable substances.

We may add, that while vegetable and animal substances susceptible of fermentation make part of the living vegetable or animal, they undergo fermentation only in a slow and insensible manner; because they are preserved from it by the vital motion, and because this slowness is necessary for the vegetable and animal economy: but when the life of organised bodies ceases, then, as nothing in their juices or proximate principles prevents their disposition to change their nature and to be decomposed, all these substances sensibly acquire the fermentative motion, and pass with more or less rapidity and regularity through the periods of change which they have still to undergo, according to the concurrence of circumstances which generally favor fermentation.

According to this idea, fermentation, taking it altogether, would be nothing else than putrefaction; to which all animals and vegetables naturally and continually tend, during their life, slowly and insensibly; but after their death, quickly and sensibly.

At the beginning of this article we observed what the necessary conditions were for fermentation of any body, and hence the means by which it may be prevented or suspended are easily deduced. These means are, intense cold, want of air and of water, and, lastly, a disproportion of the principles of the body exposed to fermentation.

The most fermentable liquors, as the juices of grapes and other ripe fruits, do not ferment when exposed to too great cold. The blood and flesh of animals are preserved from corruption by frost. They may be also preserved under the exhausted receiver of an air-pump, or by drying perfectly. They may particularly be preserved by this latter method any time, without suffering the least alteration.

We are to remark upon this subject of preventing fermentations in fermentable substances, that when only the necessary degree of heat is employed to deprive them of their superabundant moisture, and their composition consequently is not changed, we may, by mixing them again with the proper quantity of water, restore to them the same tendency to ferment which they had before they were dried. This observation is particularly applicable to matters susceptible of the first and last degrees of fermentation, and we ought to conclude

from thence, that although the products of the spirituous and alkaline fermentation are more volatile than water, yet the fermentable substances contain no principle which is not less volatile than water.

The last method of preventing or retarding fermentation in fermentable substances is, as we said, to change the proportion of their proximate principles, which is conveniently done by mixing them with some substance which can unite itself to these principles, and which is not itself fermentable. Such are spirit of wine, acids, and even all saline substances. For this reason wine is preserved in the same state by penetrating it with sulphureous acid; and also animal matters are preserved from corruption by mixing them with spirit of wine, common salt, or any other salts.

Those vegetable and animal substances only are properly fermentable which contain oil. The action of minerals, or of their principles on each other, nor even the action of decomposed vegetable and animal substances, can be considered as true fermentations, except we so far extend the meaning of the word fermentation as to include the spontaneous and intestine motion of decomposing pyrites, by which new salts are formed; the changes produced upon the imperfect metals by air and by water; the rancidity of oils; and other changes, which appear to differ essentially from the fermentation of animal and vegetable matters.

The effervescences which happen betwixt bodies not much compounded, when they mutually dissolve each other, such as the effervescences perceived when acids unite with earths, alkalis, or metals, are much more different from true fermentation, and have never been confounded together but by persons entirely ignorant of chemistry.

We may judge from what we have said concerning fermentation in general, how important this matter is for the attainment of a knowledge of animal and vegetable substances; but we cannot form an adequate notion of it, without considering attentively the particular phenomena which appear in the several kinds or degrees of fermentation. Wherefore, upon this *chapter*, *KINGDOM (VEGETABLE), KINGDOM (ANIMAL), WINE, SPIRIT OF WINE, TARTAR, VINEGAR, and PUTREFACTION*, may be consulted.

**CCXCV. FILTRATION and FILTERS.** Filtration is an operation by which the heterogeneous parts mixed with a liquor are separated, or by which certain matters are freed from an useless liquid. Filtration is generally performed by means of filters. A heap of small parts of any substance, as sand, may also be employed for filtration in some cases.

The rules of filtration are very simple. The chief of these are, that the filter shall contain nothing which the liquor that passes through is capable of dissolving; that it shall not be liable to be attacked or corroded by the liquor; and that its pores shall be smaller than the particles of the matter to be separated from the liquor.

A liquor cannot be filtrated unless its fluidity and thinness be proportioned to the pores of the filter. Liquors which are viscid and thick, as syrups and mucilages, and those which are very thick, as very strong solutions of some salts, do not pass, or with great difficulty, through filters whose pores appear otherwise sufficiently large in proportion to the fineness of their parts. This proceeds from the adhesion which these parts have to each other.

The



The filtration of these liquors is generally much forwarded by heat. Strong solutions, for instance, of salts, large proportions of which are soluble in water, as nitre, Glauber's salt, and others, require to be filtrated when boiling hot.

When the parts of a matter diffused in this liquor adhere to this liquor, they cannot be separated by filtration. This adhesion must be previously destroyed. For instance, the expressed juices of plants are impregnated with a resinous, earthy, fine matter, adhering to these juices, and destroying their transparency. The whey of milk also is turbid from the many fine caseous parts adhering to it. These liquors cannot be clarified by filtration without a previous preparation; for they cannot pass through the pores of a filter close enough to retain the heterogeneous particles which disturb their transparency; and through a filter open enough to give them passage, they would pass in their turbid state.

Such liquors are rendered capable of filtration by coagulating and collecting of eggs mixed and boiled together with these turbid liquors. Whites of eggs, when they coagulate, collect and agglutinate the heterogeneous parts, which then appear in larger molecules, and float freely in the liquor without adhering to it. This liquor is then in a state of filtration, it passes clear, and the matter which rendered it turbid remains upon the filter. The fine caseous parts which disturbed the transparency of whey are so well mixed in it, that, besides whites of eggs, some cream of tartar must be added, to procure the required

clarification. These are collected by boiling and still better by whites of eggs mixed and boiled together with these turbid liquors. Whites of eggs, when they coagulate, collect and agglutinate the heterogeneous parts, which then appear in larger molecules, and float freely in the liquor without adhering to it. This liquor is then in a state of filtration, it passes clear, and the matter which rendered it turbid remains upon the filter. The fine caseous parts which disturbed the transparency of whey are so well mixed in it, that, besides whites of eggs, some cream of tartar must be added, to procure the required clarification.

used as filters are woollen stuffs, linnen cloths more or less and paper. The form of filters varies according to the quality and quantity of the matter to be filtrated. Some of them are hollow inverted cones, and are used in pharmacy and cookery than in chemistry. The filter most frequently used in chemistry is paper, in the making of which no paste or size has been employed.

only of matter is to be filtrated, the paper must be in the form of a funnel, and to be placed in a glass funnel, the filter and the sides of the funnel, to prevent immediately and in all its extent to the funnel, a cloth is to be fixed to the four corners be stretched tight: to the cloth is fitted

paper, upon which

The first sort

is the

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of the filter,

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filtration are almost always more or less used again upon the filter, and even after clear. This happens because the pores afterwards contracted by the swelling occasioned by the sediment which is

**COKEVI. FIRE.** Chemists consider fire, as also the other elements, in two very different views: first, as it enters into the composition of many bodies, of which it is a principle or constituent part; and secondly, as being pure, free, not entering into any compound, but acting sensibly and strongly upon all natural bodies, and producing effects as a powerful agent in all chemical operations.

operations. In this latter point of view we shall consider fire in this article. It will be considered as a principle under the article PHLOGISTON.

Pure, free, uncombined fire seems to be a collection of particles, the matter of which is simple, homogeneous, and entirely unalterable. All the properties of this element shew that its particles are infinitely small, have no sensible adhesion to each other, and that they have a very rapid, continual motion in all directions, which is essential to them.

From this definition, fire appears to be a body essentially fluid, and many facts concur to prove that it is the only body essentially fluid, consequently the cause of the fluidity of other bodies; and that as it alone counterbalances the general tendency of all the other parts of matter towards each other, they are prevented by it from uniting into one immense, homogeneous, and perfectly hard mass.

Whence can so astonishing a difference proceed between the properties of the primitive integrant molecules of fire, and those of the integrant parts of all other matter? Is fire then not material, or not composed of matter, as its properties have induced some philosophers to think? Is it matter of a peculiar kind? Or does, as a great geometrician thinks, the attraction of the parts of matter become negative, and changed into repulsion, when these parts become infinitely small, and can come infinitely near to each other, which seems very probably to be the case with the particles of fire?

We have not facts enough to decide concerning these different opinions. We shall, therefore, confine ourselves to investigate the essential properties of fire, chiefly those which influence most in chemical operations and chemical phenomena.

Fire can with great facility penetrate, or separate itself from, any body however dense; that is, any body whatever may be heated by exposure to fire; or cooled to its former temperature, by removing it from that exposure.

From this effect we may infer the infinite mobility of the integrant parts of fire; and we may perceive the cause of its equal distribution through all bodies, when it is not determined by some particular cause to penetrate one body in greater quantity than another.

In fact, all substances whatever, which are placed in any given degree of heat, and obliged to remain there, acquire precisely the same degree of heat. This fact has been ascertained by instruments fit for measuring the degrees of heat.

The effects which the fire produces, or rather excites in bodies, upon our senses, are sensations of heat and light; but these sensations are not excited but when the fire is in a certain quantity, for every known body contains a certain portion of uncombined fire, and yet not any body which is not heated or strongly heated, excites in us any sensation of heat or light. Besides, in certain circumstances, a body may appear luminous, although it has no more sensible heat than the surrounding bodies. This is proved by the effects of several phlogistic bodies, such as the scales of fish, rotten wood, glow-worms, all which shine in the dark, although no more heated than the surrounding bodies. Also certain substances may be so penetrated with free and active fire, as to excite sensations of heat, and even to burn, although they do not appear luminous even in the dark. Amongst these substances are stones, metals, and even water,

water, all which may be so heated as to excite pain to persons touching them, although they are not luminous.

Hence we ought to conclude, that the sensations of heat and light are in many cases insufficient to prove the presence of any given quantity of fire in bodies.

We ought also to remark, that although all bodies penetrated with much fire are necessarily hot and luminous, heat, and not light, is the only certain sign of the presence of fire. The reason of this is, that bodies may be very luminous, without any change being induced into any of their essential qualities in these two contrary states; whereas the difference of more or less heat produces in all bodies alterations of their properties very sensible and proportionable to the difference of heat.

These considerations seem to have induced some philosophers to imagine, that light is a being which is indeed rendered sensible by fire, but distinct and different from it. According to this opinion, heat is only a property of fire; whereas light is a distinct and independent substance. This opinion appears to be even demonstrated, when we consider that light may be decomposed by refraction, as Newton's experiments shew; and that it is not, as pure fire is, capable of pervading all bodies, as proved by the opacity of many bodies, and by the reflexion of light.

However that may be, heat occasions more or less sensible changes in the qualities of all bodies; and that its whole action by which it influences any body consists in the fluid quality, or, to speak more accurately, the essential fluidity of fire, of which heat is only an effect; we ought here only to consider the general effects produced by fire upon all bodies by heating them more or less.

These effects, although diversified, depend nevertheless on one principle and primary change produced upon all bodies, by which they are rarefied or made to occupy a larger space. In fact, every solid and fluid body, when penetrated by a greater or less quantity of disengaged fire, is more or less increased or diminished in size than it was before.

This principle has suggested to philosophers several different instruments by which the dilatation or heat of bodies, or rather the heat which is the cause of it, may be measured; and quantities of fire, too small to be estimated by our senses, may be appreciated. The chief of these instruments is the THERMOMETER; *vide ibid.*

As bodies are dilated by fire, their specific gravity must consequently be diminished, and the adhesion of their integrant parts must also be diminished. See AERIALITY, INTEGRANT PARTS, and GRAVITY.

These two great effects produced by fire upon all bodies, are the most important and most necessary to be considered, relatively to chemistry. We may indeed say, that they are the only effects; for excepting combustion, which is a peculiar property of inflammable bodies, every chemical operation is performed either by a diminution of specific gravity, or by a greater or less disjunction of the integrant parts of bodies, as we shall see.

Some substances are capable of a greater dilatation or diminution of their specific gravity, than others, by fire. Thus certain matters are so much rarefied by even a moderate heat, that they seem to lose all their specific gravity, or become

become at least specifically lighter than all the surrounding bodies : hence these substances, when heated to a certain degree, are raised as bodies would be without gravity. All substances which have this property are called in general *volatile substances*. See VOLATILITY. Other bodies are so little dilatable by fire, relatively to their density, that the greatest heat that can be given to them produces an almost insensible diminution of specific gravity. These are called, from their being almost unalterable in this respect by fire, *fixed bodies*. See FIXITY.

Hence, if we expose to fire a compound body containing some fixed and some volatile principles, the former becoming specifically lighter ought to rise in vapors, and to separate themselves from the latter, which are unalterable in this respect. But as almost all compounds contain principles differing so much in volatility and fixity, that some of them may be raised and sublimed, while others shall remain fixed with some given degree of heat ; we may therefore, by heat alone, make many analyses and decompositions. If, for example, we expose a compound of regulus of antimony, which is a volatile semi-metal, and of gold, which is a fixed metal, to a heat so strong that the volatility of the regulus of antimony shall take place ; then this semi-metal, being raised by its acquired levity, will be sublimed in vapors, and will be separated from the gold, which will remain fixed and pure. See DISTILLATION, SUBLIMATION, EVAPORATION.

The observation we have just made concerning the changes in the specific gravity of bodies, which the dilatation occasioned by heat produces, ought also to be applied to the diminution of the adhesion of their integrant parts, which is an effect of the same cause ; for if a body be dilated by heat, the contiguity, and consequently the adhesion, of its integrant parts must be diminished : but in this respect the several natural substances differ very much ; for the integrant parts of some bodies, when dilated by heat, are so separated and disjoined, that they seem no longer to cohere. If these bodies be naturally solid, they become fluid when they are penetrated with a sufficient quantity of disengaged fire, and are called *fusible bodies*. Those bodies, the integrant parts of which cannot be entirely disjoined by fire, are called infusible or refractory : but as the aggregation of a body is broken when it is fused, and as this destruction of aggregation is a necessary condition for the combination of bodies with each other, fire therefore, by rendering solid bodies liquid, has influence as a principal agent in all combinations. See COMBINATIONS, SOLUTIONS, FUSIBILITY, and REFRACTORY.

As all chemical operations may be reduced to decompositions and combination, fire is therefore in chemistry, as in nature, an universal agent. Thus we know that, although decompositions and analyses may be made by menstrua without any more than the natural heat, yet as those menstrua can only act when rendered sufficiently fluid by heat, fire therefore acts in these analyses as necessarily as in those which are occasioned by the immediate application of heat.

We ought to observe concerning this subject of the volatility, fixity, fusibility and infusibility of bodies, first, that all these qualities are properly only relative. Not any body is entirely fixed and infusible, and those which we consider as such would be reduced into vapors, as volatile bodies are, if they were exposed

exposed to a heat infinitely stronger than any we can excite. Thus a body will appear fixed, or infusible, when compared with other very volatile and very fusible substances; while it shall be considered as volatile or fusible, when compared with others more fixed and less fusible.

In the second place, as volatility and fusibility are effects of one and the same cause, namely, of the dilatation occasioned by the presence of a certain quantity of uncombined fire in bodies, these two qualities are properly the same, in more or less eminent degrees; and in this sense, volatility ought only to be considered as the highest degree of fusibility. Accordingly, substances which are habitually liquid, and which ought therefore to be considered as the most fusible, are all very volatile, and may be raised into vapors with very little heat; while, on the contrary, matters that are hard, and not very dilatable; those, in short, the aggregation of whose parts is the firmest and most difficultly to be broken, and which are therefore the least fusible, are also the most fixed.

The aggregation of all bodies, when reduced into vapors or fused, is broken, but more so when reduced into vapors, than when merely fused. Accordingly, the most effectual of all methods for combining substances which cannot be easily united, or which cannot be joined while the aggregation of one of them is sensibly preserved, is, if possible, to reduce them into vapors, and to make the vapors meet.

All the effects which fire produces, as an agent in chemical operations, are reducible, as we see, to those we have mentioned. The quantity of uncombined fire which flows perpetually from the sun, and diffuses itself through all its sphere, is sufficient to produce all the separations and combinations which we daily see effected by nature; but as the heat caused by the sun is very limited, chemistry would be confined almost to the contemplation of natural operations, if we had not methods by which pure and uncombined fire may be made to enter bodies, or to quit them in greater or less quantities.

The methods of increasing the quantity or the activity of uncombined fire in bodies may be comprehended in the following three:

First, by concave mirrors and by convex glasses, a number of the rays of the sun, proportionate to the size and good quality of the instruments, may be collected into one point, called the *focus*. Bodies exposed to such a focus are penetrated with an infinitely greater quantity of uncombined and active fire than they have naturally. They are then ignited, inflamed, dilated, fused, or volatilised, according to their particular natures. The heat of such a focus is the greatest that art has produced. It is even exceedingly too strong for most chemical operations, and ought to be applied to the most fixed and refractory bodies only. As such a focus is also very small and inconvenient for the performance of any operation, and as large mirrors and lenses are very rare and dear, this fire is not much used for chemical operations. Nevertheless, several very important chemical experiments were performed by collected solar heat; as the decomposition of gold, published by Flomberg, if it be true; the fusion of platina, by Messrs. Macquer and Beaumé; and of several other bodies which could not be fused by other fires, without addition of other substances, by other chemists, at different times.

Secondly, experience has long ago taught us, and even the most ignorant nations know, that heat and all the effects of fire may be occasioned by friction and

percussion of hard bodies. The heat excited by this method may be very considerable, and even comparable to that of collected solar fire. It is in general proportionable to the force, rapidity, intensity of friction and of percussion, and to the hardness of the bodies rubbed or struck. This heat is also not much used in chemical operations: it, however, frequently occurs in many chemical experiments, as in fermentations, effervescencies, and solutions. It occurs whenever bodies unite together; and is proportionable to the rapidity and force with which they act upon each other. It is produced by the friction and collision of their integrant parts; which shows, that the primary integrant parts are exceedingly hard, even in bodies generally soft or fluid; for these substances, when dissolving, produce as much heat as those which are most hard, and whose aggregation is most firm.

The third cause which produces or excites heat is the combustion of compound bodies, in the combination of which fire enters as an element or principle, and which are therefore called inflammable or combustible bodies.

The principal phenomenon presented by these bodies is, that by mere contact with any other body, inflammable or not, but which is ignited, they are kindled, inflamed, give much heat and light; in a word, produce all the same effects as the collected solar heat, or the allisions of hard bodies. This continues till the whole substance of fire, which entered into their composition, and which was inactive, has resumed all the activity of pure and uncombined fire, and is entirely dissipated.

This inflammation of combustible bodies is undoubtedly one of the greatest and most astonishing phenomena of nature: but it is also one of the most difficult to be conceived. We cannot expect to understand it well, till we know better than we do at present the essence and true state of fire when combined, and constituting a principle of the bodies containing it, called *phlogiston*. See PHLOGISTON.

We must observe at present, that as the combustion of inflammable bodies produces all the effects of fire, pure, uncombined, and active; it is also the most convenient method, by which fire can be applied by chemists to several bodies.

The most common inflammable substances, such as wood, fossil coal, charcoal, are most generally employed in chemistry, in the arts, and in the ordinary purposes of life, in all operations where fire is requisite.

As chemists have occasion to employ all the several degrees of heat, from the weakest to the strongest, they have discovered methods of applying any required degree through intermediate substances, and still better by the disposition and construction of furnaces, in which the combustible matters, and those to which the fire is intended to be applied, are contained. See upon this Subject BATHS,

COMBUSTION, FURNACES, (a)

CCXCVII. FISH. (b)

(a) See the Supplement I. article FIRE.

(b) FISH. Neuman obtained from sixteen ounces of fish analysed by distillation, thirteen ounces two drams and a half of volatile alkaline spirit, five drams of concrete salt, three drams of oil, and an ounce four drams

and a half of residuum, from which, by calcination and elixation, twenty-five grains of saline matter were extracted. The proportion of volatile salt thus obtained from fish is considerably greater than that from flesh.

CCXCVIII.



**CCXCVIII. FIXITY.** Fixity is a property, by which a body resists the action of fire, without being raised and dissipated in vapors. It is the opposite quality to volatility.

The degree of resistance which a body ought to give to fire, to entitle it to the character of being fixed, is not determined. Thus substances are considered to be fixed almost always relatively to others which are less fixed.

As we do not know the ultimate degrees of the activity of fire, we cannot say whether any bodies in nature be capable of resisting this extreme degree of fire without sublimation, or be absolutely fixed.

Those substances, however, are generally considered by chemists as absolutely fixed, which lose nothing of their quantity by exposure to the most intense heat which they can produce. The purest and simplest earthy principle is a substance of this kind, and is perhaps the only one which can be considered as naturally fixed, and is the principle of fixity of all the rest.

Chemists commonly call many substances fixed, which do not deserve that name, but comparatively with others, as we have already mentioned. In this sense, for instance, vitriolic acid is sometimes called a fixed acid, by which is only meant that it is less volatile than others. For the same reason, regulus of antimony, and other semi-metals, may be considered as fixed substances when compared with essential oils and ether, particularly in operations where they remain fixed, when exposed to a heat sufficient to evaporate essential oils or ether, whereas these semi-metals may be considered as volatile, when compared with metals properly so called.

The fixity of bodies seems certainly to proceed from their little dilatability by fire, and this defect of dilatability is occasioned by the attraction or adhesion of the integrant parts of these bodies. See **FREE and VOLATILITY.**

**CCXCIX. F L A M E.** Flame is a collection of vapors of combustible bodies actually burning, and which are themselves in the motion of combustion. (c)

(c) **FLAME** is generally said to be an ignited vapor, or red-hot smoke. Nevertheless, *Flame, Vapor, and Smoke*, are things distinct from each other, and ought not to be confounded together. We shall endeavor to describe and distinguish these, and first of *Vapor*.

By the action of certain determinate degrees of heat, with or without access of air, all liquid and some concrete bodies are so dilated, as to occupy a much larger space than before this exposure to these determinate degrees of heat; acquire a considerable expansive power, or elasticity; and become transparent and invisible. They are then properly vapors. Thus flame they remain while exposed to the same heat by which it was produced; but by application of cold, they are condensable into palpable substances, similar to those from which they were formed,

if they happened to consist of homogeneal parts, as water and mercury do; or they are condensable into palpable substances which are the constituent parts of the bodies subjected to heat. If these bodies happened to consist of parts not homogeneal, as plants do of water and essential oil. If the vapor consists of inflammable parts, it may be kindled by contact with any ignited body; by which means, together with access of air or nitrous acid, it may be made to undergo those effects which are produced upon all bodies during their combustion, namely, the decomposition of its parts, the dissipation of its phlogiston, and emission of heat and light; but vapor thus ignited, rendered visible, and in the act of combustion, by access of air, or nitrous acid, is *flame*. This flame, or vapor decomposed by combustion, is not condensable, as we may easily conceive, into such palpable substances

As bodies cannot burn but by touching immediately the air, and as for this reason they only burn at their surface, flame, which is the only truly burning part of bodies which appear in actual combustion, is always at their surface. It is luminous and ardent throughout its whole thickness, because it is only a mass of adjacent, but disunited inflammable parts, which touching the air on every side, burn altogether and throughout their whole substance.

substances as the undecomposed vapor is, but into some only of the constituent parts of these substances, the rest being destroyed by the combustion. Thus the vapor of spirit of wine is again condensable into spirit of wine; but from the flame of spirit of wine little can be obtained by condensation but the water, which was one of the constituent parts of that spirit; the other parts, especially the phlogiston, being destroyed by the combustion.

Not only the vapor of an inflammable body, but also the inflammable body itself, without being previously changed into vapor, may, by contact with an ignited body, or any other mode of application of heat, as friction, percussion, &c. together with access of air or nitrous acid, emit a flame, which consists, as in the former case, of particles of that body in the act of combustion. Thus by applying a hot iron to sulphur, we may see a flame immediately produced upon the surface of the sulphur. We may easily conceive that bodies thus kindled can only flame at their surfaces, because there only they are contiguous to air: but when nitre is intimately mixed with the inflammable substance, as in gun-powder, the whole substance, its interior as well as its exterior parts, are instantly inflamed; because the nitrous acid has, like air, the property of maintaining combustion. Hence also we may easily conceive why the external surface of a flame, by being contiguous with air, is much hotter than its internal parts, as may easily be shewn by applying any substance, alterable by heat, alternately to the exterior and interior parts of the flame of a candle, and when the flame has a considerable diameter, as of a foot or eighteen inches, and is maintained only by the air contiguous to it, as when the vapor issuing at the upper mouth of a furnace for smelting iron ore is kindled by contact of any ignited body, the flame will then be found to have a thickness only of an inch or two, while the va-

por near the center surrounded by this flame, is not inflamed, as appears from paper or other easily combustible matter being held in it without being kindled.

Smoke consists of palpable particles elevated by means of the rarefying heat, or by the force of the ascending current of air, from bodies exposed to heat. These particles vary much in their properties according to the substances from which they were produced. Vapors also rising from heated bodies, when condensed by the coldness of air or other contiguous bodies, become palpable, and therefore have the appearance, and may be considered as, smoke. The smoke arising from combustible bodies consists of parts, some of which are generally combustible, but is difficultly combustible, that a greater heat is required than they possess while they are smoke, to effect their combustion. The flame also of combustible bodies may be so cooled by the application of cold air, or other cold substances, as that the combustion of the particles composing it shall be checked, and these particles shall become smoke. Thus the flame of a candle is, by the coldness of the air, diminished more and more as it rises higher, till at last it is extinguished, before all its inflammable parts are consumed, and its point terminates in smoke.

The smoke of burning inflammable substances, when collected, is called *foot*. The smoke of uninflamable substances, or of inflammable substances not exposed to air, and consequently not burning, consists of the substances not altered or decomposed, but only divided, as the flowers of sulphur raised by heat in close vessels, and the flowers of sal ammoniac, or it consists of parts of these substances decomposed merely by heat, and not by combustion; as the flowers of sulphur and of arsenic, from the mineral containing these called pyrites, exposed to heat in close vessels; and the flowers of benzoin, sublimed by heat from the resin of that name.



No combustible body really burns without flame. Those, indeed, whose inflammable principle is firmly united with a great quantity of incombustible matter, such as charcoal or ashes almost entirely burnt, and most metals, seem to be consumed without sensible flame; but this appearance does not impose upon an accurate observer. The appearance of a body which really burns is very different from that of a body which is only made red-hot by being penetrated with a fire proceeding from some other substance, which does not itself burn. Let a bar of iron be compared with a flint, when both are taken out of a fire so intense as to give to each of them a white heat, and the surface of the metal will seem covered over with a small flame, which is indeed very low, but bright and sparkling; while nothing similar will appear on the surface of the flint. Besides, the flint will lose its vivid color much sooner than the iron. If we observe lead while it is scorified in a cupel under a muffle, we shall see in a striking manner that the metal shall be much more ardent and luminous than the cupel; although these two bodies are exposed precisely to the same degree of heat; but this difference can certainly proceed only from the small flame which necessarily accompanies the combustion of the metal; while the cupel which contains no combustible principle, and which consequently cannot burn, does not exhibit any such appearance.

All bodies, therefore, which do really burn, seem to burn with flame; but the flames proceeding from the different combustible bodies differ very much from each other, according to the nature of these bodies, and to the particular state of their phlogiston. I do not know whether the flame of any combustible body be entirely pure. Such a flame would be nothing else than phlogiston separated from all other substances, reduced into vapor, and actually ignited. The flames of rectified spirit of wine and of perfect coal seem to be the purest of all, because they are accompanied with no smoke nor fuliginous matter. Nevertheless, the flame of spirit of wine is accompanied with much water. *See SPIRIT of WINE.* All other flames are evidently mixed with heterogeneous substances, which discover themselves by different qualities.

The least pure of all flames is that of oils and of all oily matters, because it proceeds from very compound bodies. This flame is always mixed not only with all the volatile principles of the oil, or oily body, but also with a considerable quantity of the fixed principles which are raised by the deflagration. Besides, although it is considerably luminous, all the phlogiston which it contains is not burnt: a portion of it remains combined in the state of coal with earth. Hence the flame of all oils is accompanied with a fuliginous smoke, which blackens bodies that it touches. As this property belongs to the flames of all oils and oily matters, and to none else, it is a mark by which we may discover whether the phlogiston of any body be in an oily state. *See OIL, FULIGINOSITY, SMOKE, and SOOT.*

The flame of metals is also accompanied with a sensible smoke, which is even very considerable and thick in certain metals. But this flame does not, like that of oils, blacken substances which it touches; because metals are not in an oily state. *See METALS.*

Lastly, the flame of sulphur would be very pure, if it was not for the vitriolic acid, a large quantity of which is mixed with it. Perhaps the flame of this compound would be very pure, if the sulphur was previously mixed with

fixed alkali to absorb the acid, in Stahl's manner, and if it was made to burn so weakly as not to be capable of kindling combustible bodies. See SULPHUR.

CCC. FLINTS. See EARTHS (VITRIFIABLE). (d)

CCCI. FLOWERS. By this name is generally understood bodies reduced into very fine parts, either spontaneously, or by some operation of art, but it is applied chiefly to volatile solid substances, reduced into very fine parts, and into a kind of meal by sublimation.

Some flowers are nothing else than the bodies themselves, which are sublimed entire, without suffering any alteration or decomposition: and other flowers are some of the constituent parts of the body subjected to sublimation, as we shall see in the following articles, when we define the principal matters distinguished by the name of flowers.

CCCI. FLOWERS of ANTIMONY. Antimony, which is a mineral composed of the semi-metal called regulus of antimony and sulphur, is entirely volatile, and capable of being sublimed into flowers.

To make flowers of antimony, an earthen pot or large crucible, in the upper and lateral part of which is an opening, is placed in a furnace, and three or four aludels are fitted to it. The pot is to be made red-hot, and powdered antimony is to be thrown into it through the lateral opening, and the sublimation is then to be made. These projections of antimony are to be repeated till the operator judges that the inner surface of the aludels is sufficiently covered with flowers, which are to be detached from thence with a feather.

The vessels employed for this sublimation must not be exactly closed, for two reasons; first, that access of air favors and accelerates all sublimations, and particularly this. Lemery observes justly, that the operation is accelerated greatly by directing a blast of wind upon the surface of the antimony. In the second place, if the vessels were perfectly closed, they would be burst by the expansion of the vapors, or of the contained air.

Although flowers of antimony be composed of regulus of antimony and of sulphur, as the antimony itself is, they nevertheless differ from it essentially in many respects. They have not the same metallic brilliancy. Their color is different shades of white, grey, and yellow. They are powerfully emetic. These

(d) FLINTS are semi-transparent or opaque stones, generally of a roundish form, and covered with a white crust, of a smooth, uniform, shining texture, so hard as to strike fire with steel; calcinable by fire, so as to become white, brittle, and, according to Henckel, heavier than before calcination; not soluble by acids; and vitrifiable only by the violent heat of the largest speculum, such as that of Vilette, and not even by the focus of a lens of Tschirnhaus, according to an experiment of Neuman. They are found generally in beds of chalk and of sand, but never forming entire strata of rock, as jasper does. By long exposure to air and to the sun, they seem to decay, to lose their

lustre, their firmness of texture, and to be changed to a white calcareous earth or chalk. Hence they are almost always found covered with a white chalky crust. They are also convertible into calcareous earth by fusion, or vitrification with so much fixed alkali, that they shall resolve into a liquid mass called the liqumens of flints, and by precipitation from the fixed alkali by means of acids. See LIQUOR of FLINTS.

Flints are of the class of earths called vitrifiable, because these earths are generally employed, together with fixed alkali, as materials in the making of glass. See GLASS, and EARTHS (VITRIFIABLE).

differences prove that antimony sustains a considerable alteration by this sublimation. This alteration consists in the diminishing the connexion betwixt the sulphur and the regulus of antimony.

The difference of colors in flowers of antimony proceeds from the variable action of the fire and of the air upon this mineral during the operation. Probably the emetic quality of flowers of different colors also differs. But this difference has not been observed, as the flowers of antimony have not been much employed, because of their uncertainty.

**CCCIII. RED FLOWERS of ANTIMONY.** Lemery gives a process for making the red flowers of antimony. It consists in distilling eight ounces of antimony, mixed with fourteen ounces of sal-ammoniac, or of flowers of sal-ammoniac. Some volatile alkali is raised from the sal-ammoniac, and red flowers are sublimed.

The portion of volatile alkali which rises in this operation is disengaged by the reguline part of antimony, and as one part of this volatile alkali acts at once upon the sulphur and upon the regulus of antimony, an antimoniated volatile liver of sulphur is formed. These red flowers are a kind of kermes, and differ from the ordinary kermes in having a volatile instead of a fixed alkali. They are emetic, purgative, diaphoretic, incisive, &c. as kermes is, and may be given in the same dose as kermes is; but are seldom used. However, a kermes made with volatile alkali may have peculiar virtues, and deserves the attention of physicians; but in this case it ought to be prepared in a more certain manner by employing uncombined volatile alkali.

**CCCIV. FLOWERS (ARGENTINE) of REGULUS of ANTIMONY.** To make these flowers, regulus of antimony is put into an unvarnished earthen pot, which is to be placed in a furnace so that its bottom may be red-hot, while its upper part shall be much colder. The pot is to be covered with a lid, without luting it, and heat is to be applied during an hour or more. When the pot is cold, its internal surface, and also the remaining part of the regulus, is found covered with white flowers, in form of beautiful, transparent, and shining needles. These flowers are to be gathered with a feather. After this, a second sublimation may be commenced, and managed as the former was; and thus the whole regulus may be changed into flowers, which requires much time.

Lemery directs that a small lid or diaphragm shall be placed within the pot, at the height of three or four fingers thickness above the regulus. But this appears to be unnecessary. Mr. Beaumé does not use this second lid. He only inclines the pot so, that all the upper part of it shall be out of the furnace. He makes the bottom of it very hot; and thus obtains a large quantity of flowers.

These flowers appear to be nothing else than the earth of regulus of antimony deprived of almost all its phlogiston. They are not emetic nor purgative. They are not very volatile, and cannot easily be reduced into regulus. They are soluble in aqua regia. All these properties, together with their remaining degree of volatility, shew that they contain some inflammable principle. They have the considerable marks of a saline substance. They have not only the appearance of a crystallized salt, but are also entirely soluble in water.

water, as Mr. Beaumé observes; although a large quantity of water, which must also be boiling, is required for that purpose. Eight ounces of boiling water are capable of dissolving half a grain of these flowers. From this property we may suspect that regulus of antimony contains a saline matter as one of its constituent parts, which is conformable to the opinion of some chemists concerning salts and metals.

Nevertheless, if we consider that regulus of antimony cannot be deprived of all the sulphur with which it is united in its mineral state, we may suppose that part of the acid of sulphur may, by uniting with the earth of the regulus of antimony, give the saline qualities to the flowers of this metallic substance.

CCCV. FLOWERS of ARSENIC. The white flowers of arsenic are nothing but white arsenic itself; which being a volatile substance, unalterable by sublimation, may be raised altogether, without any change.

Flowers of arsenic are made, as all other flowers are, by subliming arsenic. See SUBLIMATION.

We ought to observe that they are not perfectly white, unless the arsenic from which they have been sublimed has been perfectly dephlogisticated and white. If the arsenic which is sublimed be mixed with a little sulphur, the flowers will be more or less yellow, or red, according to the quantity of sulphur which is sublimed along with them. If the arsenic be in a reguline state, or considerably phlogisticated, its flowers will be more or less greyish or brown. Hence we see veins of these different colors among the arsenic which is found in commerce, and which is obtained by sublimation in great works from arsenical minerals.

As arsenic is very fusible, when these flowers fix themselves to any substance considerably heated, they suffer a kind of fusion, are agglutinated together, and form the dense, compact, heavy, shining masses which are in the shops of druggists. The nature and properties of flowers of arsenic do not differ from those of arsenic. See ARSENIC.

CCCVI. FLOWERS of BENJAMIN, or BENZOIN. To make flowers of benjamin, let a quantity of benjamin be put into a varnished earthen pan, which is to be covered with another inverted pan of stone ware. The edges of these two pans ought to have been ground upon a stone, so that they fit well to each other. They are to be luted together with paper dipped in paste. The earthen pan containing the benjamin is to be put upon a gentle fire, and which is not capable of raising the oil of the benjamin. With that heat the sublimation is to be performed: when the vessels are cooled, they are to be unluted, and great care is to be taken that they be not shook. If the sublimation has been performed, the inner surface of the upper earthen pan will be found covered with fine sparkling flowers like a very pure salt, forming crystals like flattened needles. A considerable quantity also of these flowers is generally found, which are not raised, and which cover the surface of the remaining benjamin. The flowers are to be swept off with a feather.

The success of this operation depends on the degree of heat given, and the time employed. If the heat be too great, a part of the oil of benjamin will rise together with the flowers, which will thence receive a dirty yellow tinge. In this case they must be again sublimed, and with a less heat. If, on the contrary,

trary, a sufficient degree of heat is not given, or the operation has not been long enough continued, all the flowers which the benjamin is capable of furnishing will not be procured. The same benjamin will, by repeating the operation, furnish more flowers.

The process formerly used to make these flowers consists in putting the benjamin in an earthen pot, to the mouth of which is fitted a paper, or pasteboard conical head. But the method described above, which is proposed by Mr. Beaumé, seems to be preferable: because the paper or pasteboard heads absorb many flowers, which are consequently lost, and also because the earthen vessel employed by Mr. Beaumé has a greater surface than that not used in the ancient method: and quantity of surface is always favorable to sublimation.

The flowers of benjamin are a true concrete, volatile, and only essential salt of benjamin. They have the smell of benjamin, and are inflammable, from the essential oil which enters their composition. They are soluble in water and in spirit of wine, which frequently proves their saline nature. Accordingly, Mr. Geoffroy observes, that this salt may be obtained by treating benjamin with water, and by crystallization.

Benjamin is probably not the only resin from which an essential salt of this kind may be obtained: perhaps, even all resins contain such essential salt, in greater or less quantity: and this is certainly one of those which contain a great quantity of it.

Flowers of benjamin are considered in medicine as incisive, dividing, and favoring excretion, and are therefore given in the viscous asthma. They may be given from six grains to three drams.

**CCCVII. FLOWERS OF SAL AMMONIAC.** The flowers of sal ammoniac are nothing else than sal ammoniac sublimed: for this semi-volatile salt suffers no decomposition by sublimation. The process for making these flowers consists nothing singular, excepting that an equal part of decrepitated common salt is generally mixed with the sal ammoniac, in order to divide this latter salt, and to facilitate its sublimation. By this sublimation, sal ammoniac may be purified from sulphurous and other matters, with which it is generally mixed. But it may be better and more conveniently purified by solution in water, by filtration, and by crystallization. For this salt has the property of melting, during which sublimation very fixed matters, as we see from the example of the flowers of sal ammoniac mixed with copper and with iron, which are more volatile than sal ammoniac, and which are separated from it.

**CCCVIII. FLOWERS OF SULPHUR.** Flowers of sulphur are crystals of sulphur, which are separated from its impurities. Sulphur cannot be decrepitated, because it is not volatile in itself. Therefore flowers of sulphur are obtained by sublimation, from either of pure sulphur in masses, or from its impurities.

**CCCIX. FLOWERS OF ZINC.** Flowers of zinc are the metallic crystals of zinc, which are separated from its impurities, and raised by high fires from its impurities.

To make the flowers of zinc, it is to be put into a large open crucible, set in a furnace which burns of coal. When a white heat is raised, the zinc kindles and burns with a white, vivid, dazzling flame, accompanied with a considerable quantity





**CCCXI. FLUIDITY.** Fluidity is the state of a body whose integrant parts are so disunited and incoherent, that no sensible resistance is opposed to their separation in any direction; but which are nevertheless sufficiently attracted by each other, to remain adjacent, and to form an aggregate body.

Hence fluidity is a middle state between hardness, in which the integrant parts of bodies adhere together firmly, and the entire want of aggregation, in which the integrant parts of bodies are so separated and removed from each other, that their mutual attraction is no longer sensible.

kept till their colors are lost, their infusions acquire a red color from acids, and a green color from alkalis, but to a less degree than when the flowers were fresh. The red color produced by acids is scarcely more intense than the original blue, applied upon other bodies, and exposed to air, it gradually degenerates into a faint purple, and at last disappears, without leaving stain behind. The green produced by alkalis changes to a yellow, which does not fade in time. The green made by lime-water is more permanent and beautiful. Green lakes prepared from these flowers by means of lime-water have been used by painters. The flowers of *anemone* have been much commended for affording orange and blue pigments. But Dr. Lewis has not been able to extract from them any blue color. They retain their color, when hastily dried, longer than other blue flowers, but do not communicate their original color to any menstruum.

Red flowers readily communicate their color to water, and make it a full red color give to a solution of steel a deep red tincture, though somewhat paler than the watery infusion. But the light red flowers, and those which are purple, impart little color to pure spirit. The colors of infusions of these flowers disappear, to be heightened by acids, and to be rendered green by alkalis. The colors are not uniform, for some are tinged by acids with the red color, and by alkalis with the green. By acids, some of the flowers give a full red, and some a purple color. Some of the purple flowers give a green color to a green color. The colors of these flowers are not uniform, for some are tinged by acids with the red color, and by alkalis with the green. By acids, some of the flowers give a full red, and some a purple color. Some of the purple flowers give a green color to a green color.

nated with a solution of alum and of tartar, produces, on being boiled with the watery infusion or decoction, a durable yellow dye. A durable yellow lake is prepared by precipitating weak alum an infusion of yellow flowers made in an alkaline ley. In some of the orange-colored flowers the yellow matter seems to be of the same kind as that of the pure yellow flowers; but the red matter seems to be different from that of the pure red flowers. The yellow matter is extracted from these flowers by water; and the remaining red matter is extracted by spirit of wine, or by a weak solution of fixed alkali in water. Such are the saffron-colored flowers of *Carthamus*. These flowers, after the yellow matter has been extracted by water, are said to give a red tincture to ley, from which a deep red colour is obtained, called *safflower*, *Spanish red*, and *Chimichili*. This pigment gives a beautiful red color to spirit of wine, but none to water. The yellow farina or fine dust, settling on the tips of the lamina of flowers, gives a fine bright yellow color to spirit of wine, and a duller yellow color to water. The colors of both the watery and spiritous infusions were heightened by acids rendered red by acids, and again rendered yellow by adding an alkali. This is the only remarkable instance of the yellow color of a vegetable being rendered red by acids.

Watery decoctions, or their expressed juices, impart a green color to alkaline leys, but have not been observed by Dr. Lewis to give a red color to acids. The white flowers of the common wild *campanula* give a deep yellow or orange color to water, which is heightened by acids, and by alum, as the infusion of yellow flowers are. The *campanula* of *Armenia* gives a beautiful yellow color to water acidulated with spirit of nitre.

A body may be fluid in two manners; first, by the figure of its primitive integrant parts, so that each of these parts shall not touch any other but in one point, or in one infinitely small side, and consequently have but little or no adhesion. Such a body must necessarily and naturally be fluid. Fire seems to be the only body possessed of this essential fluidity.

The second manner by which a body may be rendered fluid is, to lessen the contact of the integrant parts, to disjoin them, or even to separate them from each other by the interposition of a fluid. All bodies, which can only be fluid in this manner, are evidently not essentially fluid. On the contrary, they are naturally more or less hard and solid, and can only have a mediate or secondary fluidity. Such all bodies in nature appear to be, excepting fire. Hence, without fire no fluid would exist; all bodies would cohere together, and form a single, solid mass; and hence fire is the principle of all fluidity. But when a body is rendered fluid by fire, it may then be capable of giving fluidity to other bodies. Water, for instance, the fluidity of which is certainly caused by fire, may by interpolating itself betwixt the integrant parts of gums and salts, give to them a fluidity similar in some respects to its own.

We must not confound the fluidity received directly from fire with the fluidity received from bodies rendered fluid by fire. Some substances are incapable of receiving fluidity directly from fire, but only through the intervention of some other substance previously rendered fluid by fire. Such are gums, which are rather decomposed than rendered fluid by fire, but which are readily soluble in water. Other bodies may be either rendered fluid directly by fire, or secondarily through the intervention of another body previously rendered fluid by fire. Such, for instance, are salts. They become fluid when exposed alone to the action of fire, and are also capable of liquefaction by water.

The principal difference betwixt a body rendered fluid merely by the action of fire, and another body rendered fluid by the interposition of a fluid substance, is, that the integrant parts of the latter body adhere to those of the interpolated substance; and that this adhesion or affinity is the cause of the fluidity of that body.

This secondary fluidity, therefore, given by interposition of a fluid substance, is nothing else than a solution. The fluidity given immediately by fire is called by chemists, *fixum*; we therefore say that a salt is dissolved in water, but not fused or melted. This latter expression is frequently used, though very improperly.

There evident and important difference betwixt the fluidity of fire, which is essentially fluid, the fluidity of bodies rendered fluid by the action of fire, and the fluidity of bodies rendered fluid by the interposition of another fluidly fluid, require that these different kinds of fluidity should be distinguished by names appropriated to each. We cannot so richly enrich our language as has been used to denote them. Bodies naturally fluid must be called *fluida*, and those which have only a secondary fluidity must be called *soluta*. But when we wish to give to the primary and essential fluidity of fire, we must call it *fixum*.

This want of suitable expressions shows the little attention given by the ancients and natural philosophers to fluidity, and to the properties of bodies by which they give and receive fluidity. From the having ascribed to the properties of fire, and upon this earth which is produced upon these bodies,



we have considered those substances as having an independent fluidity, which we have generally seen in a fluid or fused state, such as air, ethereal spirits, mercury, spirit of wine, and even water and oils; although we frequently see these two last mentioned substances become solid by cold, or want of active fire. The fixation of mercury by a sufficient degree of cold, the possibility of which is suspected in the *Elements of the Theory of Chemistry*, and is ascertained by experiments of some members of the Academy at Petersburg, induces us to conjecture, that every body is naturally solid or hard; and that all fluid bodies receive their fluidity from fire, which is the only substance essentially fluid.

However that may be, this is evident, that as the aggregation of every body which is solid or liquid must be broken, or much diminished, fluidity is the most favorable state for the formation of new unions; and that every substance which forms a new combination must necessarily have or acquire this state. Therefore a precise and accurate knowledge concerning fluidity, and the properties of bodies by which they give and receive fluidity, is exceedingly important in chemistry. **See AGGREGATION, SOLUTION, FUSION, FUSION, and LIQUEFACTION.**

**CCCXII. FLUOR.** This word, used as an adjective, is applied to signify the latent fluidity of any substance, or that property by which a substance can be rendered fluid, and is employed as an epithet to distinguish such substances from others of the same kind, but which are habitually solid, or which may be rendered solid. Acids, for instance, which are habitually fluid, as all the mineral and some vegetable acids, are called *fluor acids*, in order to distinguish them from the acids of tartar and acid essential salts, which are naturally concrete. Alkali volatile mixed with quicklime, or with metallic earths, so that it is always liquid and not crystallized, is called *fluor volatile alkali*, to distinguish it from the concrete and crystallizable volatile alkali.

By *fleur*, used substantively, is meant a certain kind of stone which is fusible, or which facilitates fusion. Such are the greater part of stones, which are called *fleurs*. Thus, for example, in talking of a white or colored spar, which is found in the matrix of an ore, we say that this matrix is mixed with a white, green, or yellow *fleur*. See *Sens* (f).

CCCXIII. **FLUX**. This word is sometimes used synonymously with *fusion*. For instance, an ore, or other matter, is said to be in liquid flux, when it is completely fused.

But the word *flux* is generally used to signify certain saline matters, which facilitate the fusion of ores, and other matters which are difficultly fusible, in essays and reductions of ores. Fixed alkalis, nitre, borax, tartar, and common salt, are the saline matters of which fluxes are generally composed. But the word *flux* is more particularly applied to mixtures of different proportions of only nitre and tartar, and these fluxes are called by particular names, according to the proportions of these ingredients, as we shall see in the following articles.

CCCXIV. **FLUX (WHITE)**. White flux is made with equal parts of nitre and of tartar detonated together, by which they are alkalinized. The residuum of this detonation is an alkali composed of the alkalis of the nitre and of the tartar, both which are absolutely of the same nature. As the proportion of nitre in this mixture is more than is sufficient to consume entirely all the inflammable matter of the tartar, the alkali remaining after the detonation is perfectly white, and is therefore called *white flux*, and as this alkali is made very quickly, it is also called *imperfect alkali*. When a small quantity only of white flux is made, as a few ounces, for instance, some nitre always remains undecomposed, and a little of the inflammable principle of the tartar, which gives a red or even a black color to some parts of the flux: but this does not happen when a large quantity is made of white flux, because then the heat is much greater. This small quantity of undecomposed nitre and tartar which remains in white flux is not hurtful in most of the metallurgical fusions in which this flux is employed: but if the flux be required perfectly pure, it might easily be disengaged from these extraneous matters by a long and strong calcination, without fusion. See **CALCINATION**.

CCCXV. **FLUX (CRUDE)**. By crude flux is meant the mixture of nitre and tartar in any proportion, without detonation. Thus the mixture of equal parts of the two salts used in the preparation of the white flux, or the mixture of one part of nitre and two parts of tartar for the preparation of the black flux, are each of them a crude flux before detonation. It has also been called *white flux*, from its color, but this might occasion it to be confounded with the white flux above described. The name therefore of crude flux is more convenient.

that they were fusible. I have also by a very considerable heat, fused some of these white opaque fluxes, which are said to be similar to the *shih-ku*, or *shih-ku* stones, of which the Chinese compose their porcelain.

5. With much more moderate heat they greatly facilitate the fusion of calcareous and argillaceous earths, and as the crude, according to Mr. Pott. For which quality they have been much employed in the making

ing of bricks, as they produce the fusion of the calcareous earth.

6. When heated slowly and gradually, they emit a white smoke, which is said to be very useful in the preparation of the *shih-ku*, or *shih-ku* stones, and in the making of porcelain. The heat which is produced in the fusion of these fluxes, is not sufficient to melt the most refractory matters, but it is sufficient to melt the most common matters, and to facilitate the fusion of the most difficult matters.

Crude flux is detonated and alkalised during the reductions and fusions in which it is employed, and is then changed into white or black flux, according to the proportions of which it is composed. This detonation produces good effects in these fusions and reductions, if the swelling and extravasation of the detonating matters be guarded against. Accordingly, crude flux may be employed successfully in many operations; as, for instance, in the ordinary operation for procuring the regulus of antimony.

**CCCXVI. FLUX (BLACK or REDUCING).** Black flux is produced from the mixture of two parts of tartar and one part of nitre detonated together. As the quantity of nitre which enters into the composition of this flux is not sufficient to consume all the inflammable matter of the tartar, the alkali which remains after the detonation contains much black matter, of the nature of coal, and is therefore called *black flux*.

This flux is designedly so prepared, that it shall contain a certain quantity of inflammable matter; for it is thereby capable not only of facilitating the fusion of metallic earths like the white flux, but also of reviving these metals by its phlogiston. From this property it is also called *reducing flux*; the black flux, therefore, or crude flux made with such proportions of the ingredients as to be convertible into black flux, ought always to be used when metallic matters are at once to be fused and reduced, or even when combustible metals are to be fused, as they require a continual supply of phlogiston to prevent their calcination. See Nitre, Tartar, and Fluxes.

**CCCXVII. F O R G E.** An ordinary forge is nothing but a pair of bellows, the nozzle of which is directed upon a smooth area, on which coals are placed. The nozzle of a pair of bellows may be also directed to the bottom of any furnace, to excite the combustion of the coals placed there, by which a kind of forge is formed. In laboratories, there is generally a small furnace consisting of one cylindrical piece, open at top, which has at its lower side a hole for receiving the nozzle of a double bellows. This kind of forge-furnace is very convenient for fusions, as the operation is quickly performed, and with few coals. In its lower part, two inches below the hole for receiving the nozzle of the bellows, may be placed an iron plate of the same diameter, supported upon two horizontal bars, and pierced near its circumference with four holes diametrically opposite to each other. By this disposition, the wind of the bellows, pushed forcibly under this plate, enters at these four holes, and thus the heat of the fire is equally distributed, and the crucible in the furnace is equally surrounded by it. This contrivance is used in the forge-furnaces for melting copper, with this difference only, that these furnaces are square, which is a matter of no consequence.

As the wind of bellows strongly and rapidly excites the action of the fire, a forge is very convenient when a great heat is to be applied quickly: but it is not suitable when the heat is only gradually increased.

The large, or blast of bellows, is used in several operations in small, as, to fuse calcareous matters, &c. &c. It is also much used in works in the great, which require a strong heat, with much management, and chiefly in the melting of ores, and fusing of metallic matter.

**CCCXVIII. F L A T T E R.** This is a mixture of several substances intended to be fused together for the purpose of making glass. After these substances have been

been mixed together, they are generally exposed during a certain time to a more or less strong heat, which is, however, incapable of completely fusing them. The intention of this operation is either to effect a slight union betwixt the matters, or to free them more perfectly from any inflammable or extraneous matter, by this calcination. See VITRIFICATION.

### CCCXIX. FRUITS. (g)

CCCXX. FULIGINOSITY. By this word is meant soot, or the black matter which accompanies the flame of oils and of oily substances. See SOOT.

CCCXXI. FULMINATION. Fulmination is the sudden and violent explosion and inflammation of certain bodies, which are therefore called *fulminating*. Such are the explosions of fulminating powder and of fulminating gold. The explosion of these matters is called *fulmination*, from the noise accompanying it, by which it resembles thunder.

CCCXXII. FURNACE. Furnaces are chemical instruments used for containing combustible matters, by the burning of which the heat requisite for operations is procured; and also for containing the substances themselves to which the heat ought to be applied.

As chemists require for different operations all the possible degrees of heat, from the weakest to the strongest, and as the form of furnaces contributes

(g) FRUITS are considered only as *coloring materials* in this article, the greatest part of which is extracted from a note of Dr. Lewis to his Translation of Neuman. The red juices of fruits, as of *currants, mulberries, elder berries, morella and black cherries*, when inspissated and dried, may be again dissolved in water, to which they give nearly the same red color as they do when fresh. Rectified spirit extracts the tinging particles, and acquires a brighter color than the watery solution; because much of the mucilage is left undissolved by the former. The red solutions and the juices are sometimes made dull, and sometimes more florid, by acids, and are generally rendered purplish by alkalis. The colors of these juices are generally perishable. They are not destructible by the fermentation of the liquors, but they quickly decay when the juice is spread thinly on any substance, and kept in open air. The bright lively reds are soonest changed. The dark, dull red stain of the black cherry is considerably durable. The bright red fruit of the *spinosa* or *prickly pear* is an exception to the above rule; as it gives, according to Lebat, a beautiful red dye. The ripe berries of *holothorn* stain paper of a green color. From these is prepared the substance called *sap-green*, which

is a pigment sufficiently durable, soluble in water, but not miscible with oil. The same berries dried whilst green, and macerated in alum-water, are said to yield a yellow pigment, and when they have grown over-ripe, a purple pigment. Wooden cloth, prepared with alum and tartar, receives, on being boiled with the berries, a perishable yellow dye. The *French berries*, or *grains d'anguon*, one of the most perishable yellow dyes, is a berry of the species of buckthorn. It is said, that the berry of the *Delicetophan griseum* stains paper of a green color; and that this green is soon changed to a blue; that the common blue paper receives its color from this juice; and that the red sage called *tunsef*, employed for coloring wines and other liquors, are tinged by the same juice turned red, by acids. Mr. Nettle says, that the coloring juice is obtained, not from the berries, but from the roots of the plant. The Dutch are said to prepare their reds from other materials, of which *vermilion* is a principal one.

The seeds of some plants, as of *cray*, are covered with a fine shining red membrane. The pith of the seed of an American tree affords the red matter called *amery, urican, and ruman*. See *Amery*.

greatly,

greatly, as we shall see, to produce the different degrees of heat; they have contrived many furnaces of different forms and constructions; but all these furnaces may be reduced to a small number of general dispositions, which we shall now describe.

The *simple furnace* is a kind of hollow tower, cylindrical or prismatical, with two doors or principal openings; the one below, called the *door of the ash-hole*; and the other immediately above this, called the *door of the fire-place*. Betwixt these two doors a grate is placed horizontally across the interior part of the furnace, dividing the whole cavity of the furnace into two parts: the lower part is called the *ash-hole*, because it receives the ashes which fall from the fire-place. The door of the ash-hole gives admittance to the air necessary for maintaining the fire within the furnace. The upper cavity of the furnace is called the *fire-place*, because it contains the combustible matters. Through the door of the fire-place, fresh fuel is to be introduced, to supply the place of what is consumed.

This simple furnace, similar to that used in kitchens, is sufficient for many chemical operations. In the fire-place, amidst the coals, crucibles may be placed for the fusion of fusible matters; such as lead, tin, bismuth, &c. or for the calcination of matters which require but little heat for their calcination; such as the alkali for making Prussian blue, bezoar mineral, &c.

On this furnace may also be placed basons for evaporations, alembics for distilling in the water-bath, pots filled with sand for digestions and distillations to be performed by means of a sand-bath and a gentle heat, either with alembics or with retorts.

As several of the operations made with this furnace are of long duration, and as the furnace requires a continual supply of fuel; chemists have contrived to adapt to it a magazine of coals in form of a hollow tower, closed in its upper part, and so disposed, that, while the coal of the fire-place is consumed, that of the tower falls down and supplies its place. The furnace thus disposed is called an *athanor*, or the *furnace of fluggards*. See ATHANOR. See PLATES.

The *lamp-furnace* is a kind of athanor, in which the heat is produced and maintained by the flame of a lamp introduced within it. This furnace has evidently no occasion for an ash-hole, a grate, or a fire-place. It has only one opening below, through which the lamp is introduced, and a kind of small chimney made in its upper and lateral part, for circulation of air, to keep up the flame of the lamp, and to give vent to the smoke. This furnace is very convenient for distillations which require little heat. A water-bath or sand-bath may be fitted to it. It is particularly useful for digestions. See PLATES.

The *reverberatory furnace* is the simple furnace, the fire-place of which is covered with a piece of the same diameter and form as the furnace, which is generally cylindrical. This piece is crossed in its lower part by two bars of iron placed horizontally and parallel to each other, and at its upper edge it has a semi-circular cut. This piece consequently forms a third cavity, which is called the *Laboratory*, because it is intended to receive the retorts containing the matter to be distilled. The semi-circular cut is made to give passage to the neck of the retort, which, as we have said under the article DISTILLATION, ought to be inclined at an angle of 45 degrees. The use of the two bars at the bottom of the laboratory is to support the vessel placed there.

Above the piece we have now described is a fourth piece placed, the form of which is that of a spherical cap, or of an inverted dome; it is accordingly called the *dome*. This dome has an equal diameter to the other piece, to which it is to be fitted; and in its lower edge it has a semi-circular cut, which corresponds with the similar cut of the lower piece; and these together form a circular opening: the dome has in its top another opening or short tube, through which the air contained in the furnace passes, and is a kind of chimney.

The use of the dome is to keep up the heat all around the retort which is placed in the furnace, and to apply a certain degree of heat to the upper part or vault of the retort, by reflecting or reverberating it: hence it is called a *reverberatory*. By this disposition the vapors which rise in the retort are determined more efficaciously to pass through its neck. We may judge after this description, that reverberatory furnaces are only used for distillations with a retort, in which a certain degree of heat is necessary.

Distillation may be performed in reverberatory furnaces, either in naked fire, by placing the retort immediately upon the bars, or in a sand-bath, by placing upon these same bars an iron vessel, in the upper edge of which is a semi-circular cut. Into this iron vessel is put fine sand to the thickness of one or two fingers: then the retort is to be placed in it; and, lastly, it is to be filled with sand up to the arch of the retort. If the heat be required to be of a certain strength, the iron vessel must have a diameter so much less than the internal part of the furnace, that an empty space of about the thickness of a finger shall be left betwixt them, excepting on the side where the neck of the retort is; and there the hollow cuts of the furnace and iron vessel that correspond to each other ought to join exactly. See PLATES.

The *melting furnace*, or wind furnace, is intended to produce the greatest degree of heat that can be excited without bellows. This furnace ought to be so constructed, that a current of air shall constantly pass through the fire-place; and the more strongly and rapidly this air passes, the more intense will be the heat in the furnace.

The chief method for producing this effect is to leave in the upper part of the furnace a space close on every side, excepting above and below; because the air contained in this cavity being rarefied and expelled by the heat produced by the fuel burning in the furnace, a vacuum is here formed, which the external air necessarily tends to occupy from its gravity.

This being established, the furnace ought evidently to be so disposed that the external air shall be obliged to enter at the ash-hole, and to pass through the fire-place, to fill the vacuum which is continually forming both in the internal part of the furnace and in its upper cavity.

We ought to observe, that the column of air which corresponds with the upper part of the furnace, being a little shorter, and consequently lighter, than the column which corresponds with the lower part, the air appears naturally determined to enter at the bottom, and to go out at the top of the furnace; so that if this furnace was a hollow cylinder, the lower and upper mouths of which were equal, and if the fire-place was in the middle, the air would probably pass through it from bottom to top; but this difference of the two columns being almost infinitely small, the velocity of the current of air would be as small: but if, instead of this disposition, the furnace be contracted in its upper part, and if it be made to become a tube of less diameter, then the rarefied air



is obliged considerably to accelerate its course in passing through a straiter space, and thereby overcomes more easily the pressure of the superior air: hence the air introduced through the lower part of the furnace, in order to fill the vacuum which is continually forming in its upper part, passes so much more rapidly through the fire-place as it finds less obstacle above; and consequently this disposition of the furnace necessarily determines a strong and rapid current of air to pass through it, from the bottom to the top.

From what has been said we may easily perceive, that the more the space or air is rarefied in the upper part of the melting furnace, the stronger and more rapid is the external current of air which is obliged to enter the furnace to fill up this vacuum; and consequently the more intensely the coals must burn. Hence these furnaces produce so much more heat, as the tube which is at their upper part, called the *tube of aspiration*, is longer. But we must observe, that although the activity of this furnace is owing in great measure to the contraction in its upper part or to its tube, nevertheless a too great contraction of the tube would be very inconvenient, because the air rarefied, and obliged to go out at the upper part, can only acquire a certain determinate velocity: whence it follows, that if this tube, through which the rarefied air is to go out, were so strait that this air could not pass, unless it had a greater velocity than it is capable of acquiring, then the air, finding an obstacle in its way, would be retarded in its progress, and consequently too great straitness in the tube impedes rather than facilitates the course of the air: accordingly, I have found by experience, that a melting furnace to which too strait a tube, however long, has been adapted, produces little effect, compared with that caused by a tube of sufficient diameter.

Hence the diameter of the tube must have a certain relation to the capacity of the furnace, and to the door of the ash-hole. I have found that the diameter of the tube ought to be to the diameter of the furnace as 2 to 3 nearly, particularly when the tube is long enough (*b*). The opening at the bottom of the furnace may be equal in width to the body of the furnace, or it may be contracted, if the air be required to strike the fire with more force and rapidity. After all these principles, we now proceed to the construction of a good melting furnace. The body of this furnace does not differ from that of a simple furnace, except that it is, or may be open, or almost

" (*b*) The diameter of the tube ought to have a certain proportion, not to the door of the ash-hole, but to the space left by the intervals of the grate; and both these ought to bear a certain proportion to the diameter of the fire-place. The proportion mentioned by the Author, which the diameter of the tube should hold to the diameter of the fire-place, as two to three, seems to allow too great a width to the tube. When the tube is too wide, more air passes through the furnace than is necessary for the maintenance of the fire and consumption of the fuel; by which means the furnace is greatly cooled; and even, if the air should be prevented from passing through in too large a quantity, by

narrowing the door of the ash-hole, the air will pass down the wide tube, which will then contain two distinct columns of air, one ascending, and the other descending. The following proportions seem to me to be preferable: If the area of the fire-place contain 144 square inches, let the area of the tube, and the sum of the several intervals of the grate be, each of them, 36 square inches: but in certain states of the fire, for instance, when it is thoroughly kindled, the upper vent may be advantageously still further contracted by registers, by which much fuel may be saved, and the fire kept more equally intense.

entirely open, below, and supported upon feet, or a kind of tripod, which serves as an ash-hole. An elliptical form is generally given to it, with intention to concentrate the heat (*i*). The upper part of this furnace is terminated by a dome higher than that of the reverberatory furnace, called the *cap*. This cap has two openings, one of which is placed laterally and in the front; it ought to be large, and to be capable of being closely shut by a door: the other is at the top, and ought to be a tube of a convenient diameter, upon which other tubes of indeterminate length are adjusted.

This furnace has no laboratory, or rather its laboratory is the fire-place itself; for the matters to which the heat is to be applied are placed in the fire-place, and surrounded by the burning coals.

The melting furnace may have a door to the fire-place; but this door ought to be kept shut during the operations. It only serves for the more convenient examination of the condition of the crucibles or other matters placed in the furnace, and not for the introduction of fresh fuel, for which purpose the door of the cap is intended. This latter door ought to be very large, that a considerable quantity of coal may be thrown in at once. The reason why this door is preferable to the door of the fire-place for the introduction of the fuel is, that the current of air may not be disturbed in its direction; and therefore the lateral door ought to be kept open as little as possible.

When the internal diameter of such a furnace is 12 or 15 inches, when the diameter of the tube is 8 or 9 inches, and its height 18 or 20 feet, and when the furnace is well supplied with fuel, an extreme heat is produced: in less than an hour the fire will be white and dazzling, like the sun: its heat will be equal to the strongest degree of heat in a glass-house furnace. In less than two hours may be melted whatever is fusible in furnaces (*k*). The hottest part of this furnace is 4 or 6 inches above the grate.

Chemists generally believe that the power of a melting furnace is greatly increased by a wide and high ash-hole, or by bringing the air which is to enter it through a long pipe from without the house in which the furnace stands: but these advantages are either imaginary, or only relative to the vacuum formed in the upper part of the furnace. If indeed a furnace be so placed that the opening of its ash-hole shall be fitted to the mouth of a great cavity; as to a cave, for instance, in the roof of which a hole is made, into which this furnace is to be fitted; and if this cave has no other opening than through the bottom of the furnace; then a very strong current of air will pass from the cave across the furnace, although the furnace had neither cap nor tube: but we must observe, that this current of air will always be stronger if the furnace is provided with a dome and tube; and secondly, if the air be determined to pass from the cave across the furnace, even without dome or tube, this must proceed

(*i*) The inequality of the surface of the sides of the furnace would prevent any advantage from the elliptical form of furnaces, even if heat were supposed to diffuse itself, like light, only in right lines, and to be thereby capable of concentration by reflexion; a supposition, however, which cannot be admitted.

(*k*) Most fusible substances may be fused

in a much less time: nevertheless we find from M. D'Arcet's Memoir concerning the effects of a violent and long-continued heat, that by prolonging the action of fire, he had been able to vitrify substances which had resisted the most violent fires continued only during a shorter time.

only



only from the heat of the furnace rarefying the ambient air, by which the more condensed air of the cave is determined to pass through the furnace to supply the place of this rarefied air. In this case, the chamber in which the furnace is placed, serves instead of the dome and tube. This happens in a glass-house furnace. These furnaces are built upon subterranean vaults, which serve as ash-holes. The internal capacity of these furnaces is very great, and is occupied only partly by the combustible matters, and by the pots containing the glass: hence the air of the ash-hole is continually introduced there to fill this empty space: besides, the heat is always very great in the domes under which the furnaces are built; the contained air is therefore continually rarefied; so that they serve as the domes and tubes of furnaces to draw the air from the vaults.

The pipe which is sometimes fitted to the ash-hole of melting furnaces does not contribute to the draught of the furnace, excepting the laboratory in which the furnace stands be small and confined: for then the air of this laboratory, being soon heated and rarefied, becomes less proper for exciting fire than the colder external air which the pipe supplies. See PLATES.

The furnace called the *essay* or *cupelling furnace* is of a prismatic quadrangular figure, and is chiefly used to make essays of the value of silver, or of silver ores. This furnace is composed of an ash-hole, a fire-place, and an upper part which terminates it above, like a quadrangular truncated pyramid. The fire-place and ash-hole are not, properly speaking, separated from each other, because this furnace has no grate (1); hence the coals in this furnace fall to the bottom: in the lower part of the furnace are three small doors, two in the sides, and one in the front: above this latter door is a fourth door, placed like that of the fire-place of a simple furnace; and at the bottom of this door are two iron bars, placed within the furnace horizontally and parallel to each other. These bars are intended to support a muffle, the mouth of which corresponds exactly to the last mentioned door. In this muffle the cupels and vessels capable of containing the matter to be heated are to be placed.

The top of this furnace is truncated, and forms a pretty large aperture, through which the fuel is to be introduced. Some of these furnaces have a small hole in the front of this upper part, through which an iron rod is introduced to push the coals down, and which also serves to shew the state of the fire. In some of these furnaces the upper part is terminated by a short tube, which on some occasions is convenient; for although the internal capacity of this furnace, including its upper part, makes a sufficient draught for these operations, a greater heat may possibly be required, and this is effected by adapting a tube to this furnace. See ESSAYS.

Some operations, which must be made either in a muffle or in a reverberatory furnace, require the strongest melting heat. The distillation of Kunckel's phosphorus, for instance, requires a heat much superior to that of ordinary distillations. Essays also of porcelain and vitrification, which ought to be done very cleanly, and therefore under a muffle, require a very violent heat, which cannot be procured in an ordinary essay furnace. In these cases a tube may be fitted to the distilling

(1) A grate would certainly render this furnace much more convenient; in the plate therefore which we have added of this furnace a grate is represented.

or to the essay-furnaces, like that of the melting furnace; and thus as strong a heat as is wanted may be procured. See PHOSPHORUS, PORCELAIN, VITRIFICATION. (m)

Chemists have contrived many other furnaces, and some very complicated, for particular purposes; but they are mostly embarrassing, ill-contrived, and even useless: for by the furnaces above described an able operator may perform perfectly well every chemical operation.

All these furnaces may be either portable, and composed of baked earth hooped with iron rings, or covered with iron plates, if they are intended to be more durable; or they may be fixed and stationary, and made of bricks and tiles. This depends on the size and disposition of the laboratory.

The matter of all chemical furnaces is always a clay which ought to be of a good quality. Common clays do well enough for furnaces that are not intended to sustain very violent heats, by which furnaces are apt to be cracked and destroyed, even before the operation is finished, unless they are made of the most pure and refractory clay. See the clays most proper for this purpose under the article CLAY.

In these furnaces no iron bars or supports ought to be used, as that metal is very quickly melted, calcined, and destroyed. All the supports within these kinds of furnaces ought to be of the same clay of which the furnace consists. As the heat is much less in the tube than in the body of the furnace, this tube is frequently made of iron plates, excepting its lower part, which ought always to be made of clay. These tubes of iron plate have many advantages, as they are light and manageable; but they have a great inconvenience, which is, that their inner surfaces are subject to calcine; hence when much flame passes through them, scales fly off from the iron with noise; which falling upon the crucibles and muffles, dispose them to vitrify, because iron is a powerful flux to clay. The whole tube ought therefore to be made of clay.

When the tube is long, it ought to be strengthened by iron rings and hooks; but these ought to be so arranged that the tube may be lengthened and shortened, according as the greater or less heat may dispose it; otherwise it might crack.

The furnaces described in this article are employed, and are necessary, for the several operations of chemistry. Many of them are also used in the arts, in manufactures, and in works in the great: such are the furnaces for glass, pottery, porcelain, and for smelting of ores. What is peculiar to any of these furnaces may be found under the article of the art in which it is employed. In other respects their structure is conformable to the general principles established in the present article. (n)

**CCCXXIII. FUSIBILITY.** Fusibility is a quality which renders bodies susceptible of becoming fluid, when exposed to a certain degree of heat.

(m) See a plate and description of a very commodious furnace for experiments on vitrification, and on the making of porcelain, and for many other purposes.

(n) See PLATES, where several furnaces

are represented, and the descriptions annexed; in which the proper compositions for lining the insides of furnaces made of plated iron, and the methods of applying them, are related.

Fusibility is the reverse of the refractory quality; so that the less the heat is which is requisite for the fusion of any substance, the more fusible it is.

Bodies differ much from each other as to their degrees of fusibility. Some of them, as air and mercury, are so fusible that the heat of the atmosphere is always sufficient to keep them fluid; others, as some oils and water, which are naturally solid with the degree of cold marked 0 in Reaumur's thermometer, are presently melted when they are exposed to a greater heat: other substances again, as lead, tin, bismuth, &c. are habitually solid in the greatest natural heats; but are fusible with a degree of heat less than is requisite to make them red: and, lastly, others are not fusible till they become red, and even white, by heat: such are silver, gold, copper, iron, glass, &c.

As the fusion of a body is caused by the interposition of fire betwixt its integrant parts, by which their adhesion is destroyed, we cannot conceive any other cause of the greater or less fusibility than a more or less intimate contact, and a more or less strong adhesion of the integrant parts of different bodies; which are dispositions depending on the figure of these parts. *See HARDNESS and FLUIDITY.*

CCCXXIV. FUSION. Fusion is the state of a body rendered fluid by fire. *See FLUIDITY and FUSIBILITY.*

## G.

CCCXXV. GALANGAL. (o)

CCCXXVI. GALBANUM. (p)

CCCXXVII. GALLEY. This name is given to reverberatory furnaces, in which several retorts may be placed at the sides of each other. As these furnaces are oblong, and have lateral openings, they have been supposed to resemble galleys, and have thence received their name.

CCCXXVIII. GALENA. (q)

CCCXXIX. GALLS. (r)

(o) GALANGAL. The Indian root called *greater galangal* resembles ginger in smell, taste, and chemical composition. The *smaller galangal* has a stronger and more agreeable smell than the former, and a more pungent and hot taste, like that of pepper. From 16 ounces of this root scarcely two scruples of oil were obtained; and this oil possesses little of the pungency of the root. Six ounces of extract were obtained by means of water from 16 ounces of the root; and an ounce and a half from the same quantity by means of spirit of wine. The watery extract was the more pungent of the two. *Neuman.*

(p) GALBANUM is a gum-resin, containing more of a resinous than gummy matter. Spirit of wine extracted from a pound of it nine ounces and a half, and water extracted from the same quantity only three ounces. The smell, flavor, and peculiar taste of galbanum resides in an essential oil, which may be raised in distillation either by means of water or of spirit of wine. From a pound of galbanum six drams of essential oil may be obtained. This oil, or a great part of it, is of a blue color, sometimes of a deep bright blue. By exposure to air this blue color is changed to a purple. *Neuman.*

(q) GALENA is the name of a lead ore, consisting of cubic particles, and composed of lead mineralised by sulphur, with which also a little silver is almost always united. *See ORES of LEAD.*

(r) GALLS are excrescencies found upon oak trees, and are amongst the strongest vegetable astringents. Extracts made from galls, either by water or by spirit, possess all the astringency of these vegetable substances. From sixteen drams of galls fourteen drams were extracted by water; and from the same quantity twelve drams and two scruples were extracted by spirit. Galls, like other vegetable astringents, or the infusions of these substances, being added to solutions of green vitriol, or to dilute and saturated solutions of iron in any acid, change the color of these solutions to a deep blue or black. The black liquor thus produced is the basis of inks, and of many black dyes. *See BLACK and INK.* When the green vitriol is dissolved, and when the galls are infused in distilled water, or in common spring waters, the color produced by mixing them is, according to Dr. Lewis, blue: but if the smallest portion of alkaline salt be dissolved in the water, or if this water has any putrid tendency,

CCCXXX. GAMBOGE. (s)

CCCXXXI. GANGUE. Gangue is the matrix of ores. See MATRIX.

CCCXXXII. GARLIC. (t)

CCCXXXIII. GARNET. (u)

CCCXXXIV. G.A.S. This name is given by chemists to the volatile in-

tendency, however small, the color produced will be purplish or reddish. These colors, when rendered more intense, by adding more of the coloring substances to the water, appear of a black color. The blackness produced by this mixture proceeds from a coloring matter which is only diffused through the liquor, and may be separated from thence by dilution with water, and by deposition. The separation may be prevented, as is done in the preparation of ink, by adding some mucilaginous matter, as gum arabic. This coloring matter is evidently a ferruginous precipitate; for altho' it is not magnetical, it may be rendered magnetical by a slight calcination. To this precipitate some of the inflammable matter of the vegetable astringent adheres and gives color. When by calcination this adhering matter is made to combine in some measure with the ferruginous precipitate, this precipitate, though not perfectly metallized, is however sufficiently metallized to be rendered magnetical. In these properties this precipitate corresponds with the blue ferruginous precipitate, which forms Prussian blue, to which also some phlogistic matter adheres and gives color; but it differs from Prussian blue by this property, that it is soluble by acids, whereas the latter precipitate is not soluble. Thus, the black coloring matter of inks may be dissolved by acids, and their color thereby destroyed. Alkalis also destroy the blackness of inks, by dissolving the astringent or inflammable adhering matter, and leaving the iron in an ochery state, similar to the precipitates of iron, formed by adding alkalis to solutions of that metal in acids. The blackness destroyed by adding acids to ink is recovered by addition of alkalis; and conversely.

I have not found that galls precipitate other metallic substances; but I have observed, that when added to metallic solutions, the precipitates afterwards formed from these by fixed alkalis, were deeply colored, and generally purple.

(s) GAMBOS is an acid gum-resin, the gummy parts of which are so intimately

blended with the resinous, that greatest part of it is soluble either by water or by spirit of wine. It forms a beautiful yellow pigment, and is much used as such by painters. Dr. Lewis says, that it gives a beautiful and durable citron-yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as Dragon's blood is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterwards to be heated, to make the color penetrate.

(t) GARLIC. The roots of garlic contain a considerable quantity of mucilage, some resin, and a very small portion of essential oil, in which the whole smell, taste, and peculiar qualities of garlic reside. From thirty-two ounces of garlic distilled with water, Neuman could obtain scarcely half a dram of this oil.

(u) GARNET, *Granatus gemma*, is a stone ranked amongst those called gems, tho' less brilliant than any other gem; it is transparent, sometimes more and sometimes less; generally of a dark-red color, but sometimes yellowish or brown; the eighth stone in hardness from diamonds; and fusible by fire. Cronstedt forms a distinct order of the garnets and the basaltes, which he calls *terra granata*. The distinguishing property of these garnet earths is, that they are more fusible in proportion as they contain less metallic matter, and are more transparent and glassy in their texture. In other respects they resemble the siliceous order of earths. See BASALTES. All garnets contain iron; most of them contain tin also; and some, according to Mr. Swab, contain iron and lead. Their forms are various; some having six sides, and others having a greater number. To imitate garnets Neri directs, that twenty pounds of crystal frit, sixteen pounds of calx of lead, three ounces of manganese, half an ounce of saffre, should be fused together during twelve hours; and that the vitrified mass, after it is separated from any lead which may have been revived by the fusion, must be again kept in fusion during ten hours.

visible parts which escape from certain bodies, and which cannot be retained and collected, at least without great difficulty; and mixture of other substances.

Thus, for example, the noxious vapors which rise from burning charcoal, and from matters undergoing the spirituous and putrid fermentations, the volatile part of spirituous mineral waters, the spiritus rectior of some substances, such as musk, may be called the *gas* of these bodies.

The gas of most substances, particularly those which affect the nerves, seems to be nothing but pure, or almost pure phlogiston, which is disengaged from bodies without ignition. The mineral noxious vapors called *damps* may be also ranked amongst vapors called *gas*, at least those of them may which are invisible.

See DAMPS.

CCCXXXV. GELATINOUS, and GELLY. (x)

CCCXXXVI. GEMS. (y)

CCCXXXVII. GENTIAN. (z)

CCCXXXVIII. GILDING. Gilding is the art of applying exceedingly thin layers of gold upon the surfaces of certain substances, to give them the external appearance of gold.

The lustre and beauty of gold have occasioned several inquiries and discoveries concerning the different methods of applying it to different substances. Hence the art of gilding is very extensive, and contains many particular operations, and various management.

A color of gold is given by painting and by varnishes, without employing gold; but this is a false kind of gilding. Thus a very fine golden color is given to brass, and to silver, by applying upon these metals a gold-colored varnish, which being transparent, shews all the brilliancy of the metals beneath. Many ornaments of brass are varnished in this manner, which is called *gold lacquering*, to distinguish them from those which are really gilt. Silver-leaves thus varnished are put upon leather, which is then called gilt leather. (a)

(x) GELATINOUS and GELLY. See JELLY.

(y) GEMS are certain stones consisting of the *siliceous*, or what is improperly called *vitrifiable* earth, much valued for their lustre, transparency, color, hardness, weight, and rarity. These are, diamonds, rubies, sapphires, topazes, emeralds, chrysolites, amethysts, garnets, hyacinths or jacinths, beryls or aqua marinas. The order in which they are enumerated shews their relative degrees of hardness. See *sub. of these articles*, DIAMONDS, RUBIES, &c.

(z) GENTIAN. From sixteen drams of the root of gentian Neumann obtained six drams and a half of resinous extract by means of spirit of wine, which contained all the bitterness of the gentian; and from the same quantity he obtained nine drams of gummy extract, which was considerably bitter, but less so than the spirituous extract.

(a) The basis of these lacquers is a solution of the resinous substance, called seed-lac,

in spirit of wine. The spirit of wine must be very much dephlegmated; and for this purpose authors direct dry pot-ash to be thrown into it, which attracts the water, and with it forms a liquid distinct from the spirit; which being collected at the bottom of the vessel, may be separated by decanting the spirit. By this method the spirit is much dephlegmated; but, at the same time, it dissolves a part of the alkaline salt, by which it acquires color, and also communicates a property to the lacquer of imbibing moisture from air. These inconveniences are prevented by adding to the spirit of wine thus dephlegmated some calcined alum; the acid of which, mixed with the alkaline salt remaining in the spirit, and forms with it a vitriolated taste, which not being soluble in spirit of wine, falls to the bottom, together with the earth of the decomposed alum; and the superfluous alum, if more be added than is necessary. To a pint of the spirit thus dephlegmated,

Amongst the false gildings may also be reckoned those which are made with thin leaves of copper or brass, called *Dutch leaf*. In this manner are made all the kinds of what is called gilt paper.

In the true gilding, gold is applied to the surface of bodies. The gold intended for this purpose ought in general to be beat into thin leaves, or otherwise divided into very fine parts.

As metals cannot adhere well merely by contact to any but to other metallic substances, when gold is to be applied to the surface of some unmetallic body, that surface must be previously covered with some gluey and tenacious substance, by which the gold shall be made to adhere. These substances are in general called *sizes*. Some of these are made of vegetable and animal glues, and others of oily, gluey, and drying matters. Upon them the leaves of gold are applied; and when the whole is dry, the work is to be finished and polished. Wood chiefly is gilt in this manner; but it must be previously covered with ten or twelve layers of chalk, mixed with glue dissolved in water. That forms a body or coat, which hurts the sculpture and mouldings upon the wood; but is necessary for furnishing the gold with a softer support; otherwise, if the gold was applied to the wood without the interposition of this size, it would be apt to be torn and rubbed off, when burnished, that is, polished with a hard instrument, called a *dog's tooth*, to give it lustre. (b)

dephlegmated, about 3 ounces of powdered shell lac are to be added; and in a day or two, by help of moderate heat, the spirit will have acquired a reddish color. It ought then to be poured off, strained, and cleared by settling: then as much gamboge and annatto are to be added as are sufficient to give it the color required, which must be discovered by frequently trying the mixture upon silver leaf. These two substances are readily soluble in the above described tincture of lac. For the greater conveniency of mixing them in any proportion, the best method is to dissolve them separately in two quantities of the tincture of lac; and thus the color of the lacquer may be adjusted by mixing together the solution of gamboge, which is yellow, with that of annatto, which is reddish-yellow. Generally two parts of the solution of gamboge are added to one part of the solution of annatto. Saffron, dragon's blood, turmeric, and other red and yellow coloring materials, are sometimes used for the same purposes, but are not preferable to the two above-mentioned. The varnish is then to be laid, with a brush, upon the leaves of silver or of tin, previously fixed upon the piece of work by the intervention of some size; and when the varnish is dry, other layers are to be spread till it be

sufficiently thick. A varnish containing less of the coloring materials than the above is applied upon works of brass to heighten the color, and preserve it from tarnishing.

(b) When wood, paper, and such substances are to be gilded, they must be previously covered with some glutinous substance, upon which, when almost dry, gold leaf is to be applied, and pressed down with a little cotton, or hare's foot. When the matter is dry, the gold is to be burnished. When the work is required to be capable of resisting rain or moisture, it ought to be previously covered with a composition of drying oil and yellow ochre ground together; otherwise a water-size may be used, which is prepared by boiling cuttings of parchment or white leather in water, and by mixing with this some chalk or whiting; several layers of this size must be laid upon the wood, and over these a layer of the same size mixed with yellow ochre. Lastly, another mixture, called *gold size*, is to be applied above these; upon which the gold leaves are to be fixed. This gold size, the use of which is to make the gold leaf capable of being burnished, is composed of tobacco-pipe clay, ground with some ruddle or black lead, and tempered with a little tallow or oil of olives. The edges of glasses may be gilt by applying, first, a

The method of applying gold upon metals is entirely different. The surface of the metal to be gilt is first to be cleaned; and then leaves are to be applied to it, which, by means of rubbing with a polished blood-stone and a certain degree of heat, are made to adhere perfectly well. (c)

Gold is applied to metals in several other manners. One of these is by previously forming the gold into a paste or amalgam with mercury. See AMALGAM.

With this amalgam the surface of the metal to be gilded is to be covered; then a sufficient heat is to be applied to evaporate the mercury; and the gold is lastly to be burnished with a blood-stone. (d)

a very thin coat of varnish, upon which the gold leaf is to be fixed; and when the varnish is hardened, may be burnished. This varnish is prepared by boiling powdered amber with linseed oil in a brass vessel to which a valve is fitted, and by diluting the above solution with four or five times its quantity of oil of turpentine; and that it may dry sooner, it may be ground with some white lead.

(c) In this manner silver leaf is fixed and burnished upon brass in the making of what is called *French plate*, and sometimes also gold leaf is burnished upon copper and upon iron.

(d) This method of gilding by amalgamation is chiefly used for gilding copper, or an alloy of copper, with a small portion of zinc, which more readily receives the amalgam, and is also preferable for its color, which more resembles that of gold than the color of copper. Of the method of preparing the amalgam of gold, see the word AMALGAM. The proportion of mercury to gold is generally as six or eight to one. When the metal to be gilt is wrought or chased, it ought to be previously covered with quicksilver, before the amalgam is applied, that this may be easier spread: but when the surface of the metal is plain, the amalgam may be applied directly to it. The quicksilver or amalgam is made to adhere to the metal by means of a little aqua-fortis, which is rubbed on the metallic surface at the same time, by which this surface is cleansed from any rust or tarnish which might prevent the union or adhesion of the metals. The use of the nitrous acid in this operation is not confined merely to cleanse the surface of the metal to be gilt from any rust or tarnish it may have acquired; but it also greatly facilitates the application of the amalgam to the surface of

that metal, in the following manner: It first dissolves part of the mercury of the amalgam; and when this solution is applied to the copper, this latter metal having a stronger disposition to unite with the nitrous acid than the mercury has, precipitates the mercury upon its surface, in the same manner as a polished piece of iron precipitates upon its surface copper, from a solution of blue vitriol. When the metal to be gilt is thus covered over with a thin coat of mercury, it readily receives the amalgam. In this solution and precipitation of mercury, the principal use of the nitrous acid in the process of gilding appears to me to consist. The amalgam being equally spread over the surface of the metal to be gilt, by means of a brush; the mercury is then to be evaporated by a heat just sufficient for that purpose; for if it be too great, part of the gold may also be expelled, and part of it will run together, and leave some of the surface of the metal bare: while the mercury is evaporating, the piece is to be, from time to time, taken from the fire, that it may be examined, that the amalgam may be spread more equally by means of a brush, that any defective parts of it may be again covered, and that the heat may not be suddenly applied to it when the mercury is evaporated, which is known by the surface being entirely become of a dull yellow color, the metal must then undergo other operations by which the true golden color is given to it. First, the gilded piece of metal is rubbed with a scratch-brush, (which is a brush composed of brass wire) till its surface is made smooth; then it is covered over with a composition called *gilding wax*, and is again exposed to the fire till the wax be burnt off. This wax is composed of bees-wax mixed with some of the follow-

ing



Finally, some metals, particularly silver, may be gilt in the following manner:

Let gold be dissolved in aqua regia. In this solution pieces of linen are to be dipped, and burnt to black ashes. These ashes being rubbed on the surface of the silver by means of a wet linen rag, apply the particles of gold which they contain, and which by this method adhere very well. The remaining part of the ashes is to be washed off; and the surface of the silver, which in this state

ing substances; red ochre, verdegise, copper-scales, alum, vitriols, borax. By this operation the color of the gilding is heightened; but must be further improved by another operation. This consists in covering over the gilt surface with a saline compound; in exposing it thus covered to heat till the saline matters acquire a certain color and appearance, known to artists; and lastly, in suddenly quenching it when thus brought to its proper degree of heat, in urine, water, or other liquid. Different artists use different receipts for the preparation of the saline compound; but all, or most of these receipts contain nitre, sal ammoniac, or common salt, alum, or some vitriolic salt; to which they add verdegise, borax, or other matters; all which must be powdered and mixed, or boiled, with urine. Some artists think that they give an additional lustre to their gilt work, by dipping it after it has undergone the foregoing operations in a liquor prepared by boiling some yellow material, as sulphur, orpiment, or turmeric, in water or in urine, together with tartar, common salt, and other saline substances. These operations cannot be well explained, unless experiments were made to discover by what of the numerous substances used at the same time, the effects are produced. In the mean time, I will hazard some conjectures concerning this subject. The effect produced by flaming off the gilding wax is the brightening of its color; and seems to me to be caused by a more thorough dissipation of some mercury remaining after the first evaporation of it, which is well effected by this equable application of heat. The effect produced by the saline compound is that of giving the genuine color of gold, entirely similar to that of a piece of gold dipped in aqua regia, by which any smut upon its surface is dissolved, and its true color is made to appear. Accordingly, in all the receipts which I have seen

for the preparation of this saline compound, I have always found one ingredient to be nitre, another to be common salt or sal ammoniac, and a third to be alum or some vitriol. Now, by exposing these to the fire, an aqua regia is actually produced, the vitriolic acid of the alum or of the vitriolic salt decomposing the other two salts containing the marine and nitrous acids; by which means these acids are so disengaged that they can, thus formed into an aqua regia, dissolve some of the surface of the gold, and thus give it its genuine color. This action of the marine and nitrous acids upon the gold must evidently be continued but an exceeding short time; the artist therefore watches the appearance of the saline compound, which, from the urine or other substance containing some inflammable matter, becomes black, upon the application of a certain degree of heat; and then he quickly plunges it in water. Lastly, the only advantage from the last operation is, that a part of the yellow matter, as the sulphur, or turmeric, remains in some of the hollows of the carved work, in which the gilding is apt to be more imperfect, and to which it gives a rich and solid appearance.

Iron cannot be gilt by amalgamation, unless, as it is said, it be previously coated with copper by dipping in a solution of blue vitriol. Iron may also receive a golden coat from a saturated solution of gold in aqua regia, mixed with spirit of wine, the iron having a greater affinity with the acid, from which it therefore precipitates the gold. Whether any of these two methods be applicable to use, I do not know; but the method commonly employed of fixing gold upon iron is that above-mentioned, of burnishing gold-leaf upon this metal when heated so as to become blue, and the operation will be more perfect if the surface has been previously scratched or graved.

Another

does not seem to be gilt, is to be burnished with a blood-stone, till it acquire a fine color of gold. This method of gilding is very easy, and consumes a very small quantity of gold. Most gilt ornaments upon fans, snuff-boxes, and other toys of much show and little value, are nothing but silver gilt in this manner.

Gold may also be applied to glass, porcelain, and other vitrified matters. As the surface of these matters is very smooth, and consequently is capable of a very perfect contact with gold leaves, these leaves adhere to them with some force, although they are not of metallic nature. This gilding is so much more perfect, as the gold is more exactly applied to the surface of the glass. The pieces are then to be exposed to a certain degree of heat, and burnished slightly to give them lustre. (e)

These are the principal methods of gilding. *Silvering* is performed by processes very similar to these, and founded on the same principles. (f)

CCCXXXIX. GILLA VITRIOLI. This name is given to white vitriol purified by crystallization, which was formerly given as an emetic, from half a scruple to a dram. See VITRIOL.

CCCXL GINGER. (g)

Another method is mentioned by authors of gilding upon metals, and also upon earthen ware, and upon glass; which is, to fuse gold with regulus of antimony, to pulverize the mass which is sufficiently brittle to admit that operation, to spread this powder upon the piece to be gilt, and expose it to such a fire that the regulus may be evaporated, while the gold remains fixed. The inconveniencies of this method, according to Dr. Lewis, are, that the powder does not adhere to the piece, and cannot be equably spread; that part of the gold is dissipated along with the regulus; that glass is fusible with the heat necessary for the evaporation of regulus of antimony; and that copper is liable to be corroded by the regulus, and to have its surface rendered uneven.

(e) A more substantial gilding is fixed upon glass, enamel, and porcelain, by applying to these substances powder of gold mixed with a solution of gum arabic, or with some essential oil, and a small quantity of borax, after which a sufficient heat is to be applied to soften the glass and the gold, which is then to be burnished. With this mixture any figures may be drawn. The powder is for this purpose may be made, 1. By grinding gold leaf with honey, which is afterwards to be washed away with water; 2. By distilling to dryness a solution of gold in aqua regia; 3. By evaporating the mer-

cury from an amalgam of gold, taking care to stir well the mass near the end of the process; 4. By precipitating gold from its solution in aqua regia by applying to it a solution of green vitriol in water, or some copper, and perhaps some other metallic substances.

(f) *Silvering* by amalgamation is seldom practised, as it does not succeed nearly so well as the gilding by amalgamation. The common method of silvering metals, as brass, or of making French plate, is that mentioned above of burnishing silver leaves, from twenty to sixty, upon the piece of metal previously heated.

(g) GINGER. From sixteen bunces of the root of common ginger, about a dram of oil possessing the smell and flavor, but not the pungency of the ginger, may be obtained by distillation. The same quantity of root yielded with rectified spirit an ounce and two scruples of resinous extract, containing all the pungent matter of the root. Waterless extract four ounces from sixteen ounces of the root. The watery extract was considerably pungent, but it seems to receive its pungency from some part of the resin which is mixed with it, for the resin remaining in the root after the extraction by water, contains greater part of the pungent matter. *Nichol.*

## COCCXL GLACIES MARIE. (b)

CCCXLII. GLASS Glass is a hard, solid, brittle, transparent substance. It exists, when it is of a good quality, the action of air, water, acids, and all other menstrua. Lastly, it is not fusible without a very strong heat.

The large quantity of vitrifiable earth which enters into the composition of glass, gives it all these qualities. But as this earth is so difficultly fusible, when it is pure, that it cannot be fused and vitrified by the greatest fires of our furnaces, other matters, and particularly salts, must be mixed with it, by which its fusion is facilitated, and so intimate an union is formed, that it makes with them but one body. These fluxes therefore enter into the composition of glass. We only give here the definition of glass, and refer to the article VITRIFICATION for what we have to say on this important subject.

CCCXLIII. GLASS of ANTIMONY. The method of preparing glass of antimony, is by taking crude antimony with a moderate heat till no more vapors of sulphur rise, and till it be reduced to a grey ash-colored earth or calx. This calx is then to be put into a crucible, placed in a good melting furnace, and a sufficiently strong heat is to be applied during an hour, or an hour and an half, or rather till it be converted into a transparent glass. The operation may be known to have been well made, by dipping an iron rod into the crucible. In that case, some vitrified matter will adhere to the end of the iron rod, and will be capable of being drawn out into fine wire, like ordinary glass. The crucible is then to be taken from the furnace, and the glass is to be cast upon a smooth plate of copper, which ought to have been previously heated to dry it perfectly. This glass, when cold, is of a transparent hyacinthine color, more or less yellow or reddish.

The earths of all metallic matters are disposed to fusion and vitrification, when they still retain a portion of their inflammable principle. If this portion be too large, they may be melted more easily, but the mass will be opaque, and more or less approaching the metallic state. If, on the contrary, these earths are too much dephlogisticated, they are so much more refractory, as they have lost more of their phlogiston, and at last become entirely unfusible, at least in the fires of our furnaces, when so much dephlogisticated as to possess only the properties of pure earths. Therefore metallic glass ought to be considered as in a state intermediate betwixt that of metals and of earths. Accordingly the glass of antimony, like all the others, is so much more colored, fusible, heavy, and less transparent, as the antimony employed has been less calcined.

As glass of antimony is chiefly prepared for the purposes of medicine, and as its emetic quality, which is its chief virtue, depends on the quantity of inflammable principle which it retains, this glass, to be well conditioned, ought to be moderately fusible and transparent, of a hyacinthine color, not too clear, nor too deep; lastly, it ought to smoke, while it remains fused.

(b) GLACIES MARIE, or *lapis specularis*, is a transparent, laminated, selenitic or gypseous stone. For its properties see GYPSUM. Its appearance is very similar to that of talk, but differs from it in this circumstance, that the plates of which talk consists are flexi-

ble, while those of *glacies marie* are inflexible. Some of these laminated gypsums have a rhomboidal form, and are then called *selenites*, or *gypseous spar*: others have no determinate form.

When

When the glass is poured out, this smoke condenses partly in white flowers, which fix upon the surface of the glass and upon the plate of copper.

Hence the essential point for making beautiful and good glass of antimony is, to give the antimony the precise degree of calcination which is necessary; which is not very easy. Accordingly the operation sometimes fails; but the excess or defect of the calcination may be remedied. If the calx be too fusible, and if it flow into a fluid matter which is not transparent, nor is capable of being drawn out into wire, as glass is, we may conclude that the calx has not been sufficiently calcined. In this state, the fire ought to be diminished, the crucible uncovered, and, after the matter has been allowed to smoke during a certain time, the fire may be increased, and a transparent glass will be obtained. But if, on the contrary, the calx cannot be made to flow or vitrify well, this shows that the calx has been too much calcined. This fault may be remedied by throwing into the crucible about a sixteenth part of the weight of the calx, of crude antimony, and then fusing the whole. This small quantity of crude antimony not only gives phlogiston to the calx, which thereby becomes more fusible, but also some mineral sulphur, which produces the same effect; for glass of antimony seems always to retain a certain quantity of sulphur.

When the calx of antimony employed for the preparation of this glass is evidently of difficult fusion, a very strong heat ought to be applied quickly; for by being kept long moderately hot in the crucible before it is fused, it is more and more calcined, and at last rendered unfusible. Some calxes are supposed to have been too much calcined for this operation, because they were not exposed to strong fire sufficiently quickly.

Glass of antimony is more easily and perfectly soluble in acids, and particularly in oily acids, than the regulus; wherefore, when taken internally, it produces more considerable effects as an emetic. For this reason also, it is combined with cream of tartar for the preparation of *sibiated* or *emetic tartar*.

Formerly it was given medicinally without other preparation than levigation. But its use has been relinquished by prudent physicians from the violence and uncertainty of its effects, which are produced by the same causes as those explained under the article TARTAR (EMETIC). Nevertheless it is given successfully by very able physicians in some diseases, as in the colic of miners. But notwithstanding the experience which has established the use of it in these cases, probably emetic tartar might be administered with equal success and greater certainty; and, if necessary, in more frequent and larger doses than in ordinary cases. See TARTAR (EMETIC).

CXLIV. GLASS OF ANTIMONY CORRECTED /y WAX. A method has lately been practised in England to render the glass of antimony milder; and this preparation has been commended as an excellent remedy in dysenteries, and lochial hemorrhages. It is made by melting a dram of yellow wax in an iron ladle, and by adding to this an ounce of levigated glass of antimony, in a fire continued during half an hour, and just strong enough to dissipate almost entirely the wax without inflaming it. When the matter is cooled, it appears of a brown color. It is again to be levigated;

levigated, and is called the glass of antimony corrected by wax, or *vitrum ceratum antimonii*. The dose of it is from six grains to ten or twelve.

The emetic quality of glass of antimony is indeed diminished by this preparation, because the wax evidently furnishes a certain quantity of phlogiston, and approximates it more to the state of the regulus, or rather of the liver of antimony, both which are less emetic than the glass. But this waxed glass must evidently be subject to the inconveniencies of these other preparations of antimony, particularly to the inequality of their effects, and for the same reason. By introducing this new remedy, therefore, a kind of preparations essentially faulty, and relinquished for good reasons, has again been brought into use, without considering, that the diseases, for which it is recommended, proceed from different causes, and ought not to be treated with the same remedies; as Mr. Baron has judiciously remarked in his edition of Lemeiry's Chemistry.

**CCCXLV. GLASS of BORAX.** Borax is, as we have said under that article, a neutral salt, which when exposed to fire, loses the water of its crystallization; and by a stronger heat is further fusible into a matter which may be drawn out, while hot, into wire, like ordinary glass; and which when cold, has the appearance of a very white, transparent glass. Borax thus perfectly fused has been called a glass, from its resemblance to vitrified matters. This glass of borax differs nevertheless from true glass by the saline properties which it retains; it being entirely soluble in water, and again crystallizable into its original form of borax. It is susceptible of the same decompositions as borax; in a word, it does not differ essentially from borax, but only in being more dry, or deprived of water.

To obtain very beautiful glass of borax, it ought to be guarded against ashes and coals, which is conveniently done by melting it in a muffle. As this matter is very fusible, and at the same time capable of facilitating much the fusion and vitrification of sand, and other earthy matters, it is advantageously used in the essays of ores, and as an ingredient in compositions for glasses and artificial crystals. But for this latter purpose a very small proportion only ought to be used, as it imparts to glass the same property it has itself, of losing its lustre by exposure to air. Glass of borax is preferred to borax for these purposes; because it is deprived of all superfluous moisture, and is not subject to swell, as the borax is. See BORAX.

**CCCXLVI. GLASS of LEAD.** Lead is a metal easily calcinable; but it has a singular property, that when it has lost so much of its phlogiston that it cannot be reduced into metal without addition, it then retains the remaining part of its phlogiston more strongly than any other metallic matter. Hence ceruss or white lead, minium, litharge, and all the other preparations and calxes of lead, retain always great fusibility, and are much disposed to vitrification. All these matters, by a moderate fire only, are easily fused, and formed into a transparent glass of a deep yellow color. But this glass is so penetrating and so powerful a flux, that it passes through crucibles as soon as it melts; and when it has been kept long enough in the fire to be perfectly fused and vitrified, none of it is to be found in the crucible, which is then glazed over internally and externally.

This property of glass of lead proceeds from its powerful action upon all earthy matters, by which it disposes them to vitrify. Hence the difficulty of obtaining a pure glass of lead. A greater consistence must be given to it, and its activity must be repressed, by uniting it with sand, in the following manner, to render it fit for use.

Take two parts of a calx of lead, minium for instance, and one part of sand or powdered flints. Put this mixture into a good crucible made of refractory clay, baked into a very compact body. Place this crucible in a melting furnace, after having closed it well with a luted lid. This crucible is to be heated by degrees, and very slowly; not only to prevent the breaking of the crucible, to which this kind of crucible is very subject, when heated too quickly, but to hinder the matter from swelling too much, and flowing over the crucible in the beginning of the fusion. During an hour or an hour and a half, the fire must be thus managed in the beginning of the operation, and afterwards it may be encreased, to obtain a complete fusion, and continued in that state during an hour or an hour and a half; after which the crucible is left to cool in the furnace; and when it is broken, a very transparent yellow colored glass is found in it. Some chemists direct the addition of some nitre and common salt to the above mixture, as these salts promote the fusion, and the more equal distribution of the sand.

This glass, which, as we have seen, is not a pure glass of lead, but in which the lead is the prevailing ingredient, has a considerable specific gravity, and its lower part is always the heaviest. As it is very fusible, and easily re-melted with a moderate fire, and as it is besides a very powerful flux, it is advantageously employed in essays of ores to facilitate their scorification. See LEAD and VITRIFICATION.

CCCXLVII. GLASS-GALL. This is a saline matter which rises as a scum in the pots or crucibles in which glass is made.

This matter is chiefly composed of Glauber's salt, common salt, vitriolated tartar, or other neutral salts which cannot enter into vitrification, and which were originally contained in the ashes or alkalis employed in the composition for glass. Glass-gall is used to facilitate the fusion of certain ores, and in essays; but this matter must vary much, according to the kinds of alkalis or ashes from which it is produced. (i)

(i) *Glass-gall*, called also *Sandiver*, is said to contain the vitriolic acid, although no vitriolic salt was employed in the composition for the glass. The vitriolated tartar which is in all pot-ash and wood-ashes employed in the manufacture of glass, might account for the existence of vitriolic acid in common glass-gall; but Pott affirms, that by melting together fixed alkali, flints, and common salt, a salt of Glauber may be produced, which he thinks very similar to glass-gall in many of its properties; but from which, however, it differs in this, that it deliquesces by exposure to air, whereas

the salt of Glauber falls into a dry powder. Tachenius supposes that the vitriolic acid of glass-gall proceeds from the flints. Its crystals resemble, as Mr. Pott says, partly vitriolated tartar, and partly the salts of mineral water. It differs from vitriolated tartar in being more fusible, more soluble in water, and in being even deliquescent. It is used as a flux in essays of ores, and in the fusion of filings of gold or silver, in the same manner as borax is. It is even said to increase the malleability of metals. See Pott's *Dissertation on Glass-gall*.

CCCXLVIII. GOLD. Gold, called also by chemists the *Sun*, *Sol*, and the *king of metals*, is a perfect metal, of a yellow splendid color, and unalterable by all the operations of art. This is the most perfect of all metals; its principles are the best combined, and it possesses most eminently the metallic characteristics.

When gold is very pure, it has no taste nor smell, even when heated and rubbed. It loses in water betwixt  $\frac{1}{10}$  and  $\frac{1}{5}$  part of its weight. A cubic foot of gold weighs 1326 pounds. It is the heaviest of all metals, and consequently of all known bodies.

The hardness of gold is intermediate betwixt that of the hard and of the soft metals. Its ductility is surprizingly great, and exceeds that of all metals. From calculations made by experimental philosophers concerning the extension of gold upon silver, a single ounce of gold, the bulk of which is very small on account of its great weight, is found to be capable of covering and gilding perfectly a silver wire 444 leagues in length.

The gold-beater's art, by which gold is formed into such thin leaves that they are made to float in the air by a light breath, is a further proof of its great ductility, and is also a proof of its extreme opacity: for these gold leaves are still perfectly opaque. Light may indeed be perceived through them; but this is owing to cracks, which may be easily perceived upon examining the leaves, and which are occasioned by the repeated strokes of the hammer.

When gold is struck during a certain time by a hammer, or when violently compressed, as it is by gold-wire-drawers, it becomes more hard, elastic, and stiff, and less ductile, so that it is apt to be crackt and torn. The same thing also happens to the other metals by percussion and compression. Ductility and tractability may be restored to metals in that state, by making them red-hot, which is called *annealing* them. Gold seems to be more affected by percussion and by annealing than other metals.

The tenacity of the parts of gold is also much greater than of any other metal. For 500 pounds can be supported by a wire of  $\frac{1}{16}$  of an inch in diameter made of gold, but not of any other metal.

Gold is unalterable by air and by water. It never contracts any rust; and when its surface loses its lustre, this is occasioned by the adhesion of extraneous matters, and not by any destruction of the metal. The action of fire does not occasion any alteration upon gold. When exposed to fire it soon becomes red, and when it has acquired a vivid redness, like that of a burning coal, it soon melts. Its surface has then a light green color, like that of a beryl. No vapor or smoke rises from gold during its fusion; and it suffers no loss of weight by that operation, however long continued, or with the most violent fire. Kunckel kept gold in a glass-house furnace during a month, and Boyle kept some still longer exposed to great heat, without the loss of a single grain or any alteration.

Gold resists also, while its aggregation is entire, the action of the strongest simple chemical menstruums, either in the dry or in the humid way. It is not soluble either by the strongest mineral acids when they are pure, nor by sulphur, nor by alkalis. Two compound bodies, nevertheless, are powerful solvents of gold. The first is a mixture of the nitrous and marine acids, called by

chemists *aqua regia*, because it dissolves gold, the king of metals; and the second solvent of gold is a combination of sulphur with fixed alkali, called *liver of sulphur*.

The solution of gold in *aqua regia* is very easy. A very small quantity of nitrous acid, or even of inflammable matter, mixed with marine acid, gives this latter acid the property of attacking gold. Also a very small quantity of marine acid, or of any of the salts containing it, mixed with nitrous acid, renders this nitrous acid capable of dissolving a certain quantity of gold. But experience has shown, that an *aqua regia* composed of four parts of nitrous acid, and one of sal ammoniac, dissolves perfectly well a fourth or a third part of its weight of gold, according to the strength of the acid. See *AQUA REGIA*.

To make this solution, the gold is to be reduced into filings or thin plates, and put into a small matrass. Upon this gold the *aqua regia* is to be poured, and the matrass is to be placed in a sand-bath moderately heated. As soon as the *aqua regia* is sufficiently heated, it attacks the gold with all the usual phenomena which accompany solutions of metals in acids. But in this solution the effervescence is only moderate. While the *aqua regia* dissolves the gold, it acquires a beautiful yellow color, which becomes more and more intense, till it has a golden, or even an orange color. When the menstruum is entirely saturated with gold, the solution is very clear and transparent.

The power which the nitrous and marine acids acquire by their union, of dissolving gold, which neither of them have separately, is one of the most remarkable facts in chemistry, and favours much the opinion which admits the three earths or principles of Becker as the constituent parts of metals, because that fact is well explained by this doctrine. If marine acid contains the mercurial principle, as nitrous acid contains the inflammable principle; and if, on the other side, both these principles constitute metals, by their union with the earthy principle; we may easily conceive that all these metallic matters, in which the union of these principles is weak and imperfect, may be attacked indiscriminately by the nitrous and marine acids separately: because when any of these acids finds in the metallic matter the principle which is analogous to it, weakly combined, it may be capable of attacking that metallic matter, by means of this analogous principle. But if these principles be strongly united together, as many reasons concur to prove they are in gold, since it is the most perfect and indestructible of metals; then we may easily conceive that while these acids act on the gold separately, the mercurial principle may be defended from the action of the marine acid by the inflammable principle, and reciprocally the inflammable principle may be defended from the action of the nitrous acid by the mercurial principle; and that thus gold cannot be dissolved by either of these two acids separately.

But we may at the same time easily perceive, that if two acids united make a combined attack upon gold, that is, if the marine acid attacks the mercurial principle of the metal, while the nitrous acid attacks the inflammable principle, the action of this compound menstruum will be twice as strong as that of any of the two acids separately, and they may therefore perform the solution conjointly, which neither of them could do singly.

Gold



Gold receives no alteration in its composition from the acids of aqua regia. This solution is corrosive, as also all other metallic solutions are. It gives a violet color to the fingers, or to any animal matters, for the same reason that solutions of silver and mercury in nitrous acid tinge these matters black. If the solution be evaporated and cooled, yellow transparent crystals like small topazes will be formed. But if the evaporation be carried too far, the acids with which the gold is united may be driven from it by heat alone, and the gold will be left in the state of a yellow powder, called *calx of gold*.

Gold may be precipitated from its solution by those intermediate substances which generally precipitate metals from acids; that is, by alkalis fixed and volatile, by calcareous earths, and by some other metals. But volatile alkali seems to precipitate gold more easily than fixed alkalis; at least gold is very slowly precipitated from an aqua regia made without sal ammoniac by fixed alkali, but is copiously and instantly precipitated by volatile alkali. Fixed alkali also precipitates it copiously and speedily from aqua regia made with sal ammoniac; but in this case, the volatile alkali in the nitrous ammoniacal salt, contained in this aqua regia, is evidently disengaged by the fixed alkali, and contributes to the precipitation.

All these precipitates of gold, although yellow, have not a metallic brilliancy, because they retain part of the dissolving and precipitating salts. In other respects, they, and also the calx of gold above-mentioned, are nothing but gold unaltered; and when melted without addition, become entirely like the metal before it was dissolved.

Gold precipitated by a volatile alkali from its solution in aqua regia has an astonishing property, namely, its power of exploding with violence and terrible noise, when heated to a certain degree. It is accordingly called *fulminating gold*. See GOLD (FULMINATING). This property has not been observed in any other metal.

Although a mass of gold, that is, gold, the aggregation of which is entire, resists the action of simple solvents, as we have seen, we must not conclude that it is absolutely incapable of solution by any of these simple solvents. On the contrary, Mr. Margraaff has discovered, that this metal, precipitated by an alkali from its solution in aqua regia, is then rendered soluble by any, even the vegetable, acids. Besides, gold dissolved in aqua regia is not precipitated, when the proportions of the two acids of this compound menstruum are changed, by adding to this solution any quantity of nitrous or of marine acids. Lastly, gold may be dissolved in alkalis by the process of the martial alkaline tincture of Stahl; that is, by pouring into a concentrated solution of fixed alkali in water, a small quantity of solution of gold in aqua regia in which the acids are not too much saturated, the gold will be quickly seized and dissolved by the alkali.

All these experiments prove, that the just proportion and intimate connection of the principles of the gold are not the only causes which render it insoluble, or difficultly soluble by menstrua which easily attack the other metals, but that its great density and strength of its aggregation contribute also much to this effect; since, when this aggregation is broken by a previous solution in aqua regia, it easily yields to the action of other solvents.

Most metals are capable of separating gold from aqua regia by precipitation. The precipitate occasioned by adding tin is the most remarkable of these. It has not the metallic splendor, as metals precipitated by other metals generally have; but it is of a beautiful purple color, when well made. This precipitate, called *Cassius's precipitate of gold*, is used to give a crimson color to vitrified matters. See PRECIPITATE of GOLD (CASSIUS'S).

Oily, thin, ethereal substances have great affinity with gold. If a light, essential oil, and still better if ether, be poured upon a solution of gold in aqua regia, and the mixture be shook, the gold will be seen to pass into the oily matter, which will float upon the aqua regia now deprived of its metal. This is one of the best methods of making potable gold. See GOLD (POTABLE).

Neither sulphur nor fixed alkali can act separately upon gold. But the liver of sulphur, which is composed of these two substances, is also a great solvent of this metal. This solution can be well made only by the dry way. To make it succeed, gold leaves are to be mixed with liver of sulphur, put into a crucible together, and very quickly fused. The gold will be attacked by the liver of sulphur, and will very soon disappear. If this liver of sulphur thus impregnated with gold be dissolved in water, the metal remains suspended, and may be even passed through a paper filter.

This is also a method of making potable gold, the taste of which is very disagreeable, from the liver of sulphur. Stahl has written a dissertation concerning this method of dissolving gold, by which, he thinks, Moses might have dissolved and rendered potable the golden calf mentioned in scripture (k). As the liver of sulphur is decomposed by time, and changes into vitriolated tartar by exposure to the air, the gold therefore must also separate from it.

When a solution of gold in liver of sulphur is precipitated by an acid, the sulphur and gold are precipitated together; and in this case the precipitate is not white, as it is from a pure liver of sulphur, but acquires a yellow color from the gold. The gold and sulphur thus precipitated together are not united, but are easily separable by fire, which consumes the sulphur, and leaves the metal pure.

Gold may be alloyed with all metals; but these alloys are not much used, excepting with silver and copper, for coins and gold plate; with mercury, in the extraction of gold from the ore or matrix containing it, and for gilding; with lead and with regulus of antimony, for its purification by these substances.

Gold alloyed with any metallic substance is always less ductile than when pure; which observation is applicable in general to all alloys. See ALLOY.

The color of gold is considerably altered and rendered paler by silver, and is, on the contrary, much exalted and heightened by a mixture of copper. Cop-

(k) Moses was probably a good chemist, as he had been instructed in all the wisdom of the Egyptians, and possibly might have known the solubility of gold by liver of sulphur; but those persons who cannot be convinced that he was assisted by divine power, in this and all other instances of his administration, will scarcely believe that he could persuade the Israelites to swallow so fetid, and perhaps so poisonous a potion, as a solution of gold by liver of sulphur; or that he knew no better method of employing this precious calf, than by applying it as an emetic to his countrymen.

per also diminishes very little the ductility of gold, and gives it more firmness and solidity. Accordingly the alloy of copper with gold is much used.

Gold cannot be separated from silver but by exposing this alloy to the action of menstrua, which can only dissolve one or the other of these two metals, that is, acids and sulphur. *See PARTING.*

All other metals may be separated from gold by scorification with lead, by nitre, and by antimony, or rather by the sulphur of the antimony. *See the details of all these operations, under the words REFINING, CUPELLATION, PURIFICATION of GOLD, and SMELTING of ORES.*

All that we have said concerning the properties of gold ought to make us consider it as a metal, indestructible, fixed, and not to be decomposed. But this does not prove that it is a simple body, and absolutely unalterable. On the contrary, we have reason to believe that its resistance to all our operations is owing to our inability to raise a sufficient heat; and that if it were exposed to a fire infinitely stronger, suppose near the sun, or even within the sun, it would be burnt and decomposed, as the imperfect metals are, in a moderate fire, and perhaps would be reduced into vapors.

Some chemists pretend that they have been able to calcine gold. Homberg says, in the Memoirs of the Academy of Sciences, that having exposed gold to the focus of Tschirnhausen's great lens, he saw this metal smoke, and become a glass. But according to the tradition preserved in the Academy, this experiment is not sufficiently authenticated, and is one of those which require to be repeated with great care. (1)

Kunkel says, that he changed gold into an irreducible calx, by long calcination, without fusion, and by reverberation in the manner of Isaacus Hollandus. This experiment also is not very well ascertained, because no chemist has had patience enough to repeat it.

Lastly, the true alchemists do not make any doubt of the possibility of decomposing, or entirely destroying gold. Their books are filled with processes by which they affirm, that this metal may be radically dissolved; its principles separated; its sulphur, as they call it, its tincture, and its soul, may all be extracted.

In Junker's Chemistry we find, that Langelot, and Borrichius in his Treatise concerning the Wisdom of Hermes and of the Egyptians, say, that if gold leaves be triturated upon a porphyry during fourteen days and nights, the gold will at last be changed into a black powder, which contains something viscous, volatile, of a sulphureous smell, and which being distilled with a graduated heat in a shallow retort, furnishes some drops of a very red liquor.

This experiment is evidently very long, laborious, and liable to error, as most of this kind are. For it is almost impossible, but that during so long a

(1) Homberg says, that part of the gold was vitrified, and supposes only that the rest might also have been vitrified. But he did not ascertain the purity of the gold which he employed, and therefore the glass produced in this experiment might proceed from copper or other metal with which the gold might have been alloyed, or from the ashes of the charcoal which supported it; which we find was the opinion of some persons who had been present at that experiment.

trituration, a sensible quantity of heterogeneous matters should be mixed with the gold, if it were only those which are continually floating in the air. (m)

Borrichius says also in the same work, that a plate of gold, being made red-hot and extinguished in water many times, gives an astringent taste to the water, which seems to shew a kind of solution of gold by water. But was the gold, and also the water employed by Borrichius in this experiment, perfectly pure? We know with what difficulty gold can be obtained perfectly pure, and that no water but distilled water is fit for chemical experiments.

Becker, in his second Supplement to the *Physica Subterranea*, gives a process to render gold as soft as lead, and to encrease its fusibility. This process consists in throwing melted gold a number of times into a liquor composed of spirit of sal ammoniac and rectified spirit of wine. I do not believe that this experiment has been repeated by any chemist. If it succeeds, the softness and fusibility which the gold acquires may probably be caused by a superabundance of inflammable principle communicated to it by these two liquors.

The author of a treatise called *Alchymia Denudata* affirms, that if half an ounce of gold be melted with two ounces of copper, and the copper be afterwards separated from the gold with eight times as much aqua fortis not depurated, and if this work be repeated nine times, the gold will receive so lively a red color, that it would scarcely be known to be gold, and so fixed as to sustain all the ordinary trials without hurt or loss. This experiment deserves to be repeated. We do not see why the author directs the use of undepurated aqua fortis, or of such as probably contains some marine acid. Such an aqua fortis seems, on the contrary, very unfavorable to the experiment; for as it is a little of the nature of aqua regia, it may dissolve some of the gold.

Roth advances in his Chemistry, that gold may be dissolved in spirit of nitre distilled in Glauber's manner, the vapors of which have been received and condensed by highly rectified spirit of wine. In this experiment, nitrous ether must be formed, and we know that ether has a strong disposition to unite with gold: therefore this solution ought to succeed better, as the ether is here assisted by the action of the nitrous acid. But this solution of gold probably does not differ much from the ordinary tincture of gold made with nitrous ether. See GOLD (POTABLE).

Kunckel, in his Chemical Laboratory, proposes as an excellent solvent of gold, but which acts exceeding slowly, the subtle vapor which arises during the re-action of deliquated fixed alkali with vitriolic acid. This vapor seems indeed to be very subtle and active, by the impressions it makes upon our organs of smelling; but these qualities are only apparent, and we cannot easily be-

(m) Junker also relates from Borrichius and Olibander, that by a long trituration of an amalgam of gold with distilled water, a black powder was formed, which was convertible into green glass, and that the water became impregnated with a saline matter; and that by this method the gold may be destroyed. Dr. Lewis observes, that the green glass probably proceeded from abraded parts

of a glass mortar, that the saline matter had probably pre-existed in the water or was extracted from the glass, and that the black powder was produced by the trituration of the mercury. The same author says, that he has triturated an amalgam of gold during a week, without destroying any part of the gold.

lieve that this vapor is capable of dissolving gold, excepting the vitriolic acid be impure and sulphureous. I collected a considerable quantity of this vapor by saturating fixed alkali with vitriolic acid in a tubulated glass alembic. The vapor when condensed into a liquor seemed to be nothing but pure water. Its poignant smell, therefore, seems to be nothing but the air which is disengaged in all these effervescencies, and which by interposing itself betwixt the parts of the water gives this spirituous quality to the water, which Mr. Venel has shewn to exist also in the mineral, aerial, and spirituous waters. *See* WATERS (MINERAL).

Cassius, in his *Treatise de Auro*, mentions a process to obtain very red crystals of gold of a violet smell. For this purpose he directs gold leaves to be dissolved by help of a long continued heat, in a liquor composed of a pound of the phlegm of ordinary aqua fortis, and of four ounces of common salt. When the solution is made, the crystals above-mentioned may be obtained by crystallization, in the ordinary method. As this is merely a solution of gold in aqua regia, the peculiar color and smell of the crystals probably proceed from matters extraneous to this metal. Besides, marine acid when weakly attached to a basis without smell, always emits an odor similar to that of violets.

Glauber, in his *Treatise de Lapide Animalis*, gives a process for dissolving gold, by which also it is remarkably altered. This process consists in dissolving two or three ounces of hartshorn in an aqua regia made by distilling together nitre and decrepitated common salt (by means undoubtedly of some substance capable of disengaging the acids). Then a dram of gold leaf is to be put into this liquor, which is to be afterwards distilled off from the gold in a glass cucurbit, during which distillation the gold is dissolved; and when the liquor is drawn off, at the bottom of the vessel, a mass will be found composed of all the ingredients employed. This mass is then to be fused very quickly in a forge fire, and in an open crucible; by which it is changed into a black scoria, under which the gold is found rendered white and brittle like regulus of antimony. If this experiment be true, we cannot easily conceive why the gold should acquire this whiteness and brittleness, except we impute it to the mercurial principle of the marine acid; which acid, being retained by the union it forms with the earth of the hartshorn, may be supposed capable of a partial decomposition by the gold and by the fire; and thus a portion of the mercurial principle, which many chemists believe to be one of the constituent parts of the marine acid, might apply itself to the gold, and unite with it superabundantly. Such an experiment well confirmed, would certainly indicate the presence of the mercurial principle in the marine acid.

As most chemists have made wonderful experiments on gold, their books are filled with many other processes of this nature, by which very curious and interesting phenomena result, and which therefore deserve to be repeated. But as they are at the same time almost always obscure, confused, and full of tedious and embarrassing operations, they require a very careful examination. Those processes which we have described as examples of this kind were chosen as the most practicable, and which give the most hopes of success.

Mr. Limburg, who has written a Dissertation, which obtained the prize from the academy at Rouen, concerning chemical affinities, gives a table of affinities,

in which he establishes those of gold in the following manner; aqua regia, liver of sulphur, mercury, ether, silver, iron, and lead.

The principal uses of gold are well known. It is very proper to be formed into coin, and into various ornaments, from its lustre, beauty, and undestructible quality. By means of the art of gilding, much external beauty, neatness, and richness is given to many utensils and toys. A fine color also is obtained from gold for enamel and porcelain painting. Many persons have been of opinion, and many still are, that a remedy superior to all others may be extracted from gold, capable of procuring long life. The truth of this opinion is more than doubtful. *See* GOLD (POTABLE). With gold, an explosive powder more terrible and destructive than gun-powder may be made. This powder is called fulminating gold. *See* GOLD (FULMINATING). (n)

**CCCXLIX. GOLD (FULMINATING).** This preparation is gold precipitated from its solution in aqua regia. It is called fulminating, because, when it is heated or rubbed so as to acquire a certain heat, it makes an explosion similar and perhaps superior to that of thunder.

The method always used to prepare fulminating gold, consists in dissolving this metal in a sufficient quantity of aqua regia, which is generally made with spirit of nitre and sal ammoniac; from which the gold is to be afterwards precipitated by adding fixed alkali. A copious precipitate of a yellow and somewhat reddish color is soon formed. This precipitate washed and dried is fulminating gold.

The phenomenon of fulmination is certainly one of the most striking and wonderful which chemistry affords. The cause of this fulmination is not easily to be discovered. But the following facts may suggest hints to explain it.

(n) For further particulars concerning gold, *see the articles* ESSAY of the VALUE of GOLD; PURIFICATION of GOLD by ANTIMONY; PARTING; ORES of GOLD; GILDING; and ALLAY. Every thing almost that is known concerning gold, its natural history, its chemical properties, and its use in arts, are treated copiously and accurately by Dr. Lewis, in his very useful work, intitled, *Philosophical Commerce of Arts*.

We shall here make some additions to the metallurgic history of gold. 1. The color of gold is rendered paler by fusion with borax; which substance, or other flux, is used to facilitate the fusion of filings of gold. The paleness acquired by gold from borax may be prevented or corrected by fusion with nitre, or with sal ammoniac. 2. The color of gold is heightened by an allay of copper, which also encreases its hardness, and when in small quantity, as in the proportion of one to twelve, does not much diminish its malleability. Other metals render it paler. *See* ALLAY. *See* also the methods of heightening the color of gilding

at the article GILDING. 3. The malleability of gold is diminished by cooling it, when fused too hastily. To prevent which, artists heat the mould into which the gold is to be cast. 4. The malleability of gold is destroyed by fumes of lead and of most other metallic substances; and may be recovered by fusion with nitre. Many authors say that the malleability of gold is injured by the fumes of charcoal; but Dr. Lewis believes this to be a mistake. 5. Gold may be melted with a low white heat, and when melted has a bright blueish green color. Dr. Lewis observes, that although its expansion is less than that of other metallic substances with small degrees of heat, it nevertheless expands more than most of the other metals when fused; and that this property, by which it shrinks more when it becomes solid than most other metals, renders it less capable of receiving sharp and perfect figures, when cast into moulds, than silver, copper, lead, and tin, which do not shrink so much, and far less so than iron or bismuth, which expand in their passage from a fluid to a solid state.

First,

First, if gold be dissolved in an aqua regia composed of nitrous acid, and of marine acid or common salt, and to which no sal ammoniac is added; and if this gold be precipitated by fixed alkali, this precipitate does not fulminate. On the contrary, it fulminates strongly, if it be precipitated from this same aqua regia by a volatile alkali. These facts were well known to chemists. One of the menstruums employed by them to dissolve gold, is the liquor which they call *menstruum sine strepitu*; this solvent is a compound of equal parts of alum, nitre, and common salt, with which the gold is first to be ground; water is then to be added, and the whole digested, that the salts may act upon the gold. By this method the gold is found to be entirely dissolved. In this operation the vitriolic acid of the alum disengages the acids of the nitre and of the common salt, and thus an aqua regia is formed, in which no sal ammoniac, and consequently no volatile alkali, enters. Hoffman and Etmuller affirm, that if gold be precipitated by a fixed alkali from its solution in this *menstruum sine strepitu*, this precipitate of gold does not fulminate, but that it fulminates strongly when the precipitate is made by volatile alkali.

Secondly, when gold is dissolved in an aqua regia in which sal ammoniac enters, its precipitate, whether by a fixed or by a volatile alkali, always fulminates.

Thirdly, when fulminating gold is prepared, and all the precipitate carefully collected, we find that its weight sensibly exceeds that of the gold employed; that is, a fourth more of fulminating gold is obtained, than the gold which was dissolved.

Fourthly, sulphur, or vitriolic acid, or fixed alkalis, being well mixed with fulminating powder, deprive it of its fulminating quality.

The first and second of these experiments prove clearly, that in order to procure fulminating powder, a nitrous ammoniacal salt must be formed in the operation. The augmentation of the weight of the gold shews also that this ammoniacal nitrous salt applies itself to the gold during the precipitation, and incorporates with it.

Lastly, the methods, by which the fulminating property of this precipitate may be destroyed, are also capable of decomposing the nitrous ammoniacal salt. The acid of sulphur, or vitriolic acid, separates its nitrous acid, and forms a vitriolic ammoniacal salt, by uniting with its volatile alkali; and the fixed alkali disengages its volatile alkali, and forms ordinary nitre with its nitrous acid.

All these facts seem to prove, that the fulminating property of the gold is occasioned by the nitrous ammoniacal salt formed during the precipitation, and which very strongly and intimately unites with the metal. Further, this nitrous ammoniacal salt is known to be susceptible of detonation when heated to a certain degree, and without addition of any combustible matter, which property is occasioned by the quantity of inflammable matter which its volatile alkali contains. This detonation of nitrous ammoniacal salt is indeed very small, when compared with that of fulminating gold. But all explosive bodies are known to produce explosions so much the stronger as they are more confined and compressed. But the parts of the ammoniacal salt may be so combined with the gold as to be strongly included within the particles of the metal.

If the explosion of the fulminating gold only proceeds from the detonation of the nitrous ammoniacal salt which it contains, as we have reason to believe, it must certainly be the effect of the inflammation of the nitrous sulphur, in which chiefly consists the detonation of nitre. *See DETONATION of NITRE.*

Mr. Beaumé has a particular opinion on this subject. He thinks that the nitrous sulphur which occasions the fulmination of gold, is formed during the precipitation, by the union of phlogiston with nitrous acid; that this nitrous sulphur exists mixed with the gold, and ready formed before its fulmination; and consequently that the nitrous ammoniacal salt does not contribute to the production of this effect.

The chief proof which he brings to support this opinion, is, that if fixed alkali be poured upon fulminating gold, no smell of volatile alkali arises. Mr. Beaumé further affirms, that fulminating gold may be boiled in any quantity of water, provided that water be pure, that is, distilled, without loss of its fulminating quality; which experiment seems to shew, that the fulminating quality is not occasioned by any saline substance soluble in water, as the nitrous ammoniacal salt, but rather by some substance insoluble in water, as the nitrous sulphur probably is, from its analogy to vitriolic sulphur. This is certainly an ingenious thought, and we wish that Mr. Beaumé would prosecute, prove, and explain it fully, as it deserves. *See SULPHUR (NITROUS).*

But whatever be the cause of the fulmination of gold, we are certain that the explosion occasioned by it is one of the most violent which are known in chemistry. It is not necessary that fulminating gold should be touched by an ignited matter, or that it should be heated till it becomes red, to make it explode. The heat requisite for this purpose is intermediate, betwixt that of boiling water and the heat which makes metals of an obscure red color. Friction alone, and even a friction not very considerable, is sufficient to make it fulminate; and this effect is produced either in open or in close vessels. These circumstances render fulminating gold very dangerous. Several chemists, from not sufficiently knowing its effects, have been hurt or killed, while they were pounding and drying it. I was witness to the following accident. A young man, who worked in a laboratory, had put a dram of fulminating powder into a glass bottle, and had neglected to wipe the inner surface of the neck of the bottle, to which some of the powder adhered. When he endeavored to close this bottle, the turning the glass stopper round, to make it fit more closely, occasioned such a friction, that heat enough was produced to make part of the powder explode. By this explosion the young man was thrown some steps behind, his face and hands were wounded by the fragments of the bottle, and his eyes were put out. Notwithstanding the violence of this explosion, the whole dram of fulminating gold did certainly not explode. Probably even very little of it was exploded, for much of it was afterwards found scattered about in the laboratory, in its unexploded state.

A misfortune of this kind is so terrible, and at the same time so difficult to be prevented by those who are not sufficiently initiated in chemistry, that I thought a relation of this accident ought to be published.

The gold is not altered by this sudden and violent inflammation. Of this we may be assured by detonating so small a quantity of fulminating gold under a glass bell, that nothing is to be feared from the explosion. The gold may be



be afterwards observed to adhere, in its proper metallic state, to the inner surface of this bell. (o).

**CCCL. GOLD (POTABLE).** Alchemists have always believed that gold possesses admirable virtues for the cure of many diseases, and for the prolongation of life. They have consequently laboured much to procure remedies from this metal, and they have accordingly invented many preparations, any one of which, if we believe the inventor, is capable of curing all evils. But the constant observation of the most intelligent practitioners not having confirmed these pretended qualities, this metal is not employed by physicians. Many ignorant people have still the prejudice of its great virtues; and empyrics, who know how to profit by the weakness of men, keep up and strengthen this prejudice, by continually boasting of their elixirs and tinctures of gold, and of their potable gold, which they always declare to be wonderful secrets.

The indestructible quality of gold sufficiently shews, that no effect can be produced upon it in our body, for we are certain that it is voided unaltered; and it is only used in pharmacy to cover and conceal other remedies, or to give them an air of wealth and grandeur which pleases some people.

This inactivity of gold in its natural state, seems to be acknowledged by the most ignorant, for all the quacks who boast of their golden remedies declare that they can radically dissolve it. But this pretension is as useless to an intelligent physician as it is ill-founded, since the example of many other metallic matters, the virtues of which are ascertained, although they are not dissolved radically, proves that such a solution of gold, supposing even that this metal had virtues, would be very unnecessary. Accordingly when we examine the preparations given for potable gold, we find that a part of them contains no gold, and the gold which others do actually contain may be easily extracted, and reduced to its natural state.

(o) The expansion of fulminating powder seems to be more sudden and quick, but less forcible than that of an equal quantity of gunpowder. The quickness of the expansion of fulminating gold, is inferred from the loudness of its explosion, which is much greater than that of gunpowder; and from its perforating or impressing a metalline plate, upon which it is laid unconfined, and is exploded; which effect is not produced by gunpowder; the cause of which seems to be, that the force of the explosion of gunpowder is applied so slowly and gradually, that it may be communicated from the part of the plate which the powder touches to the other parts of the plate, and thus the force is resisted by the vis inertiae of the whole plate; whereas in the explosion of fulminating gold, the whole force is so suddenly applied to the contiguous part of the plate, that it is capable of perforating

or impressing that part before it can be communicated to the rest of the plate. Now, though the force applied during the instant of the explosion of fulminating gold, be greater than the force of exploding gunpowder during that instant, yet the sum of the forces of exploding gunpowder, in the several instants of its explosion, is probably much greater than the whole force of fulminating gold, because a quantity of aurum fulminans shut up in a strong hollow iron ball, and heated in the fire, did not seem to explode; while gunpowder treated in the same manner burst the ball. This experiment is related in *Dr. Birch's History of the Royal Society*, vol. 1.

Dr. Black attributes the increase of weight, and also the explosive property of fulminating gold, to adhering fixable air. See his *essay on quicklime*, amongst the *Essays physical and literary*, published at Edinburgh, vol. II.

To render gold potable, it must be previously dissolved. This may be done in aqua regia, or even in any of the acids, with proper management; but by this method gold and the other metals are rendered corrosive. This is so well known, that the preparers of potable gold affirm that their solutions are made without any acid. But as all the very thin and volatile oily substances have a strong disposition to unite with gold, and do really unite with it when they find it much divided, by their means may be made several tinctures of gold, or kinds of potable gold. If these preparations do not acquire any virtue from the gold which they contain, they have at least that of the inflammable subtil matter, which is the vehicle of the gold. See OILS (ESSENTIAL) and ETHER.

Subtle essential oils, ethereal liquors such as the vitriolic and other ethers, being mixed and agitated with a solution of gold in aqua regia have a property of depriving this aqua regia of its gold, which it seizes, so as to carry it to the surface of the liquor, where it floats upon the aqua regia. Many receipts for potable gold are upon these principles. One of these is in the Dispensatory of the Faculty of Medicine in Paris. It consists in mixing and agitating sixteen parts of essential oil of rosemary with one part of gold dissolved in aqua regia, in separating afterwards this aqua regia thus deprived of gold from the essential oil which contains it, and in dissolving this essential oil in five times its weight of rectified spirit of wine. This preparation is the same as that described in the last edition of Lemery's Chemistry, under the name of *potable gold of Mademoiselle Grimaldi*. As all essential oils have the same property of taking gold from the aqua regia, potable gold may be made with any of these, as well as with the oil of rosemary.

As ether possesses eminently all the properties of the most attenuated and volatile oils, it produces the same effect, and better than essential oils, upon the solution of gold; so that potable gold may be made by any of the ethers in the same manner as by the essential oils. Mr. Pott having perceived a smell of ether in a potable gold, sold under the name of *Drops of General de la Motte*, imagined that this preparation was made with ether. But as these drops are miscible with water in any proportion, a quality which does not belong to pure ether, this smell of ether probably proceeds from a small quantity of nitrous ether formed by the mixture of the nitrous acid of the solution of gold with spirit of wine, both which are certainly ingredients in this preparation.

All these tinctures of gold are nothing but gold in its natural state, exceedingly divided, and suspended in an oily liquor. They are not therefore, properly speaking, tinctures. Neither can they be called potable gold in any other sense than that it swims in a fluid, and is divided into so fine parts, that it may be drank under the appearance of a liquor, as Mr. Baron well remarks in his edition of Lemery.

We ought to observe, that all these preparations we have mentioned contain a certain quantity of the acids of aqua regia; and that they are, notwithstanding, apt to deposit in time a considerable quantity of the gold they contain, unless the contained quantity be very small. Gold is deposited, particularly from the mixture of ether, in its metallic state, and is even very brilliant.

Lastly,

Lastly, as gold may be dissolved and reduced into a liquor, as well by liver of sulphur as by aqua regia, a potable gold may also be made by that solvent. Nevertheless we have not seen any potable gold made in that manner, probably from the insupportable smell and taste of the liver of sulphur.

CCCLI. **G R A I N**. A grain is the smallest weight used in the ordinary operations of chemistry. It is nearly equal to the weight of a grain of corn, from which it has received its name. A grain is the 24th part of a scruple,  $\frac{1}{12}$  part of a gros, the  $\frac{1}{72}$  part of an ounce, &c. (p).

CCCLII. **G R A I N S**. The seeds of most vegetables are so called. Two principal kinds of seeds are distinguished in chemistry, relatively to the predominant substances which are obtained from them. Some of them contain at the same time a considerable quantity of mucilage and oil, which may be separately extracted from them; the former by infusion in water, and the latter by expression, or both together by trituration with water, in form of an emulsion. These are therefore called emulsive grains or seeds. Of this kind are almonds, and the seeds of almost all fruits. The other grains are called farinaceous, because they contain no superabundant oil like the former, but are entirely composed of a dry substance easily reducible into a fine powder, called meal, from which water can extract a large quantity of mucilaginous, nutritive, saccharine matter, and which is very susceptible of the spirituous fermentation. Of this kind are the grains of all gramineous and leguminous plants, the fruits of which are only coverings including grains.

CCCLIII. **G R A N I T E**. A granite is a stone formed by the cohesion of small stones of different colors, and of different natures.

This disposition constitutes it a stone composed of small particles, called grains; and hence it is called granite.

Most granites are formed by particles of quartz, spars, sand, and mica or talk, of different colors. As quartz and sand generally predominate in granites, these stones strike fire with steel, and are classed amongst the hard stones. Nevertheless, granites differ much in this respect. Granites are found in large masses. Some of them are very beautiful, when cut and polished. Many beautiful granites are found in Brittany. The most valuable granites are brought from Egypt. (q).

CCCLIV. **G R A N U L A T I O N**. Granulation is an operation by which metallic substances are reduced into small grains or roundish particles, the use of which is, to facilitate their combination with other substances.

This operation is very simple. It consists in pouring a melted metal slowly into a vessel filled with water, which is, in the mean time, to be agitated

(p) The weights mentioned in the text are French. A grain is  $\frac{1}{24}$ th part of an English troy pennyweight, or  $\frac{1}{72}$ th part of a troy ounce. See the article **WEIGHTS**.

(q) Granites are very various in their appearance, as they are in the colors and proportions of their component particles. These particles consist of common quartz, of that species of quartz called *felspar* or rhomboidal quartz, and of mica, with which also

are often accidentally mixed particles of other stones, as of steatites, basaltes, garnets, and metallic earths. The rocky summits of the highest mountains generally consist of this compound stone, or of porphyry, which is also a compound stone, and different from granite only in containing, besides quartz, felspar, and mica, a great deal of the opaque colored siliceous stone called jasper.

with a broom. Lead is also granulated by pouring it when melted into a box, the internal surface of which is to be rubbed with powdered chalk, and by shaking strongly the box, till the lead has become solid. What passes in these operations may be easily imagined. Metals are granulated because their ductility renders them incapable of being pounded, and because filing is long, tedious, and might render the metal impure by a mixture of the iron of the file. (r).

CCCLV. GRAVITY. Gravity is the property of bodies, by which they endeavor to approach each other. Thus, for example, we know that a body resting upon the earth cannot be raised but by a force superior to what is called its weight; and that this body thus raised, returns precipitately to the earth, when it is no longer supported. Men in general have always observed this phenomenon without attending to it. But philosophers have always admired it, and have endeavoured to discover its cause, but without success; which is not surprising; for we do not yet know all the circumstances attending gravity. We are not yet certain, that all the particles of matter have this property. The gravity of the air was not discovered till the last age. We will not therefore attempt to reason upon this obscure subject. But as the particular effects of gravity influence much all chemical phenomena, and as the particular gravity of the integrant parts of different substances is probably the primary cause of the action of these substances upon each other, we must enter into some detail upon this subject.

The gravity of a body may be considered in two manners. First, every body, considered as heavy, cannot be compared but to greater or less quantities of the same kind of matter. In this case, we may observe that the greater the quantity of matter of any body is, the greater is the effect of its gravity. Hence the gravity of bodies is directly as their masses or quantities of matter. The gravity of bodies considered in this view is called their *absolute gravity*, that

(r) The granulation of metals by agitation in a box, is thus explained by Cramer. The metals capable of this kind of granulation, as lead, tin, and brass, are very brittle, when they are so hot as to be almost fused. The chalk with which the inside of the box is rubbed, increases the resistance to the motion of the agitated metal, and preserves the box from being burnt. When the melted metal is shaken and dashed against the sides of the vessel, it no sooner becomes solid, and consequently exceedingly brittle, than it is shivered into a fine dust. Those metals which are rendered more tenacious by being heated almost to fusion, as gold and silver, must evidently be incapable of this kind of granulation.

The other method of granulation may be performed by pouring the metal upon a broom, interposed betwixt it and the water, by which means the fluid metal is divided into slender streams which are further broken by the circular motion of the water. See a description of an apparatus for granulating

copper for the purpose of making brass, in a note to the article BRASS. Melted metals may also be granulated by being poured from a certain height into a vessel of water, or of other fluids capable of fixing by their coldness the drops as soon as they fall, and thereby preventing them from again running together into large masses. This granulation may be thus explained. The several parts of a fluid poured out of a vessel, begin their falls at successive instants of time. The velocity acquired by each of these parts from the accelerating power of gravity, is proportionable to the time from the beginning of its fall. This acceleration of velocity produces a continual increase of the interval or space betwixt any two parts of a fluid, which have begun to fall at different times. Hence the several parts of a falling fluid tend to separate from each other, or to form distinct masses or drops; and they accordingly do separate, when this tendency is stronger than the force of cohesion by which they are held together.

is, their weight, or the constant effect of the gravity of any certain quantity of matter. Thus we judge, that the quantities of any two substances, however dissimilar, are equal, if they produce equal effects of gravity. The weight, therefore, and the quantity, of a substance are the same thing. Men have agreed to determine the weights and quantities of matter of all substances by certain effects of gravity, and have given different names to more or less considerable weights, as *grains, drams, ounces, pounds, &c.* so that two quantities of different substances, which produce the same effect of gravity, that is, of a grain, or of a dram, of an ounce, &c. are justly considered to be equal. In this sense we say, that a pound of lead is not heavier than a pound of cotton. This absolute gravity, weight, or quantity of matter of any body, is measured by means of an ordinary balance, which is a lever suspended freely on its center of gravity, which ought to be exactly in the middle of its length. Two quantities of matter, being suspended at the two extremities of the lever, are considered as equal, or of the same weight, when this lever maintains itself in an horizontal direction.

This is the best and justest method to determine the quantity of matters employed. It is much used in commerce, and in the ordinary purposes of life. It is also the only one which ought to be employed in all the operations of chemistry, which require accuracy.

In the second place, we may consider a body as heavy, relatively not only to its mass or quantity of matter, but also to the space it occupies, that is, to its bulk. A great difference is found in this respect, among natural bodies. This difference proceeds from the greater or less number or size of empty spaces, called pores, which are in every body. Bodies which are not very porous, must evidently contain under the same bulk, a greater quantity of matter than those which are more porous; and consequently a body of a certain size, but not very porous, must have a greater absolute gravity than another body of the same size, but more porous. As these differences depend on the particular species of each body, gravity estimated in this manner is called *specific gravity*. It may also be called *relative*, because we judge of it by comparing bodies with one another. This gravity is the same thing as the density of bodies. The specific gravity or density therefore of bodies, consists in the relation betwixt their absolute gravity or weight and their bulk: and the specific gravity of any body is so much greater as its absolute gravity is more considerable, and as its bulk is less; or, in the language of geometers, it is in a direct ratio of the mass, and in an inverse ratio of the size. Hence if two bodies be equal in size, they will be to each other as their real weights or masses: and if they are equal in weight or mass, their specific gravities will be reciprocally as their sizes: that is, the specific gravity of the less bulky body will so exceed that of the more bulky body, as the bulk of this latter body exceeds that of the former.

As the density of bodies is one of their internal and essential qualities, the knowledge of which contributes much to distinguish them, and to throw light upon their nature, philosophical chemists have always applied themselves to determine this matter. By this method the purity of metals, and of several other substances, the degree of concentration of acids, of liquid alkalis, of spirits, and of other solvents, may be ascertained; and thus important discoveries

may be made. For instance, they have discovered that by alloying metals and semimetals, metallic masses are formed, the specific gravity of which seldom corresponds with what it ought to be, if these metals were not condensed or expanded by the alloy. These experiments, however, are but yet begun; and we may presume that in prosecuting them, the same phenomena will be observed, and perhaps still more varied in the solutions and combinations of all other solid and liquid bodies, and that we may find by this means explanations of many obscure and interesting facts.

The specific gravity of bodies may be conveniently determined by several methods. As this gravity is only relative, and can be estimated by comparison only, a substance simple and invariable, or which at least might easily be made as pure as possible, was judiciously chosen, to the weight of which the weight of all other substances might be compared. All these conditions are found in pure and distilled water. Accordingly by weighing very accurately a determinate quantity, an ounce, for instance, of pure water in a phial, and marking precisely the space it occupies in the phial, the relation of the specific gravity of any other fluid to the specific gravity of this water may be easily determined. For this purpose, let such a quantity of this fluid be put into the phial, that it shall exactly occupy the same space which the water did, and let it be accurately weighed. As the bulk of the two substances thus compared are equal, and as their specific gravities are to each other in this case as their absolute weights, if the liquor compared with water weighs exactly an ounce, its specific gravity will be equal to that of water; and if, on the contrary, it weighs more or less than an ounce, its specific gravity will be so much more or less great than that of water, according as it shall weigh more or less than an ounce. If, for example, this bulk of liquor equal to that of an ounce of water, weighs two ounces, its specific gravity will be double that of water; if, on the contrary, this liquor weighs only half an ounce, its specific gravity will be only half as much as that of water.

This method is very just, convenient, and the best which can be employed to determine the specific gravity of liquid substances, from the facility with which they may be all reduced to an equal bulk. But some management and address are requisite to give precisely the same bulk to two solid bodies. To do this precisely we may even affirm to be impossible; therefore another method must be used, to determine the specific gravities of solid bodies. We have observed, that the specific gravity of bodies of equal bulk are to each other as their absolute gravities or weights, and upon this principle the method we have explained is founded; but now when the masses or weights of two or more bodies are equal, their specific gravities are to each other in the inverse ratio of their bulks. From this second principle we may more easily determine the specific gravities of solid bodies. The method used for this purpose consists in reducing the bodies to be compared to the same absolute weight, and then in comparing their bulks to each other, which is the same thing as the effects of these bulks upon the same or equal quantities of water, as we shall see.

When, therefore, the specific gravity of two solid bodies is to be determined, an equal quantity, an ounce, for example, of each of them is to be weighed very accurately in the ordinary method, whatever be the difference of their bulks. Each of these bodies is afterwards to be weighed in pure water, by the



the *hydrostatical balance*, and the difference between their real weights and their weights when they are immersed in water, that is, the loss of weight which each of them sustains by this immersion, is to be observed. These losses of weight are then to be compared; and the body which has lost the least exceeds the other in specific gravity in the same proportion that the loss of weight of the latter exceeds that of the former.

To understand well what happens in this experiment, we must remark, that if a solid body be immersed in water, and if it be left in the water unsupported, and without giving it any impulse, the bulk of this body will occupy the room of a quantity of water exactly equal in bulk to that of the immersed body; and if the specific gravity of this body be equal to that of the water, it will remain motionless in the same place where it was left, because its real weight being the same as that of an equal bulk of water, it remains suspended in the water, like an equal quantity of water, that is, counterpoised by the gravity of all the surrounding parts, and consequently at rest, and in an equilibrium. But if the specific gravity of this body be different from that of water, then no equilibrium can exist. If its weight be greater than that of the water, it must necessarily descend to the bottom of the vessel; and if it be less, it must rise to the surface of the water, and the force with which that body will rise or descend, will be proportionable to the difference betwixt its gravity and that of water. If, for example, when it occupies the place of an ounce of water, it really weighs two ounces, it will fall to the bottom of the vessel, but with a force only proportionate to the excess of its weight above the weight of water; for as it cannot fall without consequently displacing the bulk of an ounce of water, therefore one ounce of its weight will be employed in ballancing or counterpoising an equal weight of water, and the body will descend by the effect of the weight of the remaining ounce, or with half its real weight. Hence, if that body be suspended at one of the arms of a balance, it may be counterpoised by an ounce weight, placed in the scale suspended by the other arm of the balance, in air, and consequently it will appear to be one half less heavy in water, than in air.

This being established, as a body of a determinate weight loses so much less of this weight in water as its bulk is less, and as these two things are in the same relation, we may therefore substitute one for the other; and when we weigh in water two bodies of equal weight, we may judge of the relation of their bulks, and consequently may appreciate their specific gravities, by determining and comparing the diminution of weight which they sustain when weighed in water. This is much more easy and exact than a mensuration of their bulks. Thus, for example, if we weigh in water two bodies of equal weight, and if the one loses a tenth part of its weight in the water, and the other only a twentieth part, we may conclude from thence, that the bulk of this latter body is one half less than that of the former, and consequently its specific gravity is double. Because the specific gravities of bodies of equal weight are in the inverse ratio of their bulks. *See what ought to be observed in weighing bodies in water, under the article BALANCE (HYDROSTATICAL).*

From what has been said concerning the gravity of bodies, we may perceive, that in examining their nature and properties, the specific gravity only of bodies is attended to; and that the absolute gravity, or rather the weights used to determine it, are things arbitrary and conventional, which, however, deter-

mine well the absolute gravity, when they themselves are determinate and accurate. But we must observe, that weights, like measures, have a great inconvenience in not being uniform. They are fixed arbitrarily and differently in different countries; so that an ounce, or a pound, is not always the same in one country as it is in another, which necessarily introduces confusion and errors in commerce and in the arts. As weights cannot be fixed but by an exact measure or bulk of the bodies intended to be used to fix these weights, the measures must evidently be first rendered uniform in all nations, which is not to be expected. The thing, however, is very possible. The length of a pendulum, which vibrates every second under the equator, is a fixed and invariable measure to which all others may be referred, and would be very proper to be universal, if nations would agree to it. This project, the execution of which would certainly be very favorable to commerce, arts, sciences, and consequently mankind, was proposed by M. de la Condamine, in a memoir which he read at the Academy of Sciences.

To complete this article, we must examine what effects are produced by the gravity of bodies in their combinations and decompositions, that is, in all chemical operations. It is undoubtedly the most important and decisive object for the general theory of chemistry, but it is not within our province, as it cannot be well treated but by help of mathematics. In this point these two sciences, which appear so remote from each other, meet. A man sufficiently intelligent and able in both, might, by treating this matter accurately, throw much light upon it, and lay the foundation for a new physico-mathematical science; or rather, might render the application of algebra and geometry to natural philosophy much more general. Several persons, and lately Mr. Sage, in a Dissertation, which gained the prize of the Academy of Rouen, concerning the Cause of Chemical Affinities, have advanced some steps in this path; but great difficulties will probably occur. Perhaps chemistry is not yet sufficiently advanced to be subjected to calculation; perhaps even it will never be so far advanced; and although men of genius have, since the restoration of the sciences, carried mathematics to a greater perfection than it was believed could have been attained, the problems which chemical phenomena offered to geometricians may be so complicated, as to be above the reach of human understanding.

However that may be, in these latter ages a most happy application has been made of the theory of universal gravity to the system of the world, and to explain very satisfactorily the celestial phenomena. If this universal gravitation of the heavenly bodies, so happily observed, and so well calculated, be an essential property of matter in general, as many reasons induce us to believe, its effects cannot be confined to very large bodies separated from each other by immense distances, but must necessarily extend to the small particles of matter at very small distances from each other, and consequently in chemical combinations and solutions. Although we do not precisely know the bulk, the masses, the forms, nor the distances of the ingredient and constituent parts of bodies, we see them act upon each other, unite or separate, adhere more or less strongly, or resist all union; and we must believe that these effects are produced by the same power; such, for example, as the reciprocal gravitation of these small particles to each other; which is variously modified, according to their size,



size, their density, their figure, their extent, the intimacy of their contact, or the greater or less distance of their approach.

By telescopes and other instruments, astronomers have indeed discovered the size, distance, and motions of heavenly bodies; and by applying calculation and geometry to these discoveries, they have perceived the gravitation of these great bodies, and have even determined the law of that gravitation: but the microscope has been found ineffectual to shew the primary and elementary parts of bodies; and when geometers have endeavoured to apply the theory of universal gravitation to the phenomena of terrestrial bodies, they found that this gravitation did not follow the rule of the inverse ratio of the square of the distance, when this distance was very small. The law of gravitation in small distances does not appear to have been yet well determined; whether this proceeds from a want of a sufficient number of facts, or because it has not been examined by the ablest geometers. But although we cannot precisely determine this point, would it not be desirable to approximate it indirectly, and by making suppositions? This appears so much the more easy, as the velocities, the times, the spaces past, need not be observed and calculated, nor periodical revolutions to be determined: for the motions of the elementary parts of bodies, although certainly very regular, and subjected to the same fixed laws, cannot be perceived minutely, and only by their effects. They are made in indivisible instants. They are not constant, but perpetually variable, according to the circumstances which determine them. We cannot therefore consider these objects but in general, or rather in a vague manner. But, however, I ask those who are capable of deciding such questions, if, supposing that the smallest atoms of matter are affected by the same power by which the heavenly bodies gravitate to each other, may we not consider their tendency to the center of the earth as of no effect, when we attend to the almost infinite smallness of these elementary particles, and the infinitely small distance at which they may approach each other? The effect of their gravity ought in this case to be, to make them tend to each other. They are, as it were, small worlds separated from the rest; or, being at liberty to yield to their reciprocal tendency, they re-act upon each other, without being disturbed by the great counterpoise which keeps the whole universe in an equilibrium. In the second place, as the distance betwixt these molecules of bodies is infinitely small, or none at all, may not contact be substituted for it? And in this case, would not the force with which these molecules tend to each other, or adhere together, be in a compound ratio of their densities and contacts? Hence it should follow, that bodies whose primary integrant molecules should have the greatest density, and whose figure should allow them to have the most extensive and immediate contact, would be the hardest of all bodies, or those whose aggregation would be the firmest; such, for example, as we conceive that of vitrifiable stones to be; and that, on the contrary, bodies whose primary integrant molecules should have the least density, and such a figure that they could not have but the smallest possible contact, would be the least hard of all bodies, or rather would be fluid; such pure fire appears to be, and the other substances essentially fluid, if any such are.

In the third place, if we suppose substances whose primary integrant molecules have a very great density, but can have only very small contacts; whether that may depend on their figure, or the interposition of some other substance with

the parts of which they can also have but small contacts; then we may evidently perceive, that the force with which these molecules tend to unite together will not be satisfied, and consequently will be in a continual *nifus* or effort, and, if we may be allowed to say it, in a state of violence; so that when they shall have within their reach any other substance upon which they may exercise the tendency which they have to unite with that substance; that is, with which they shall have a greater contact; they will then actually unite with that substance with an activity and impetuosity proportionate to their remaining tendency to unite, or their unsatisfied gravitation. Such appear to be mineral acids, and in general all chemical solvents; the action of which cannot be conceived, unless we suppose that the force with which their integrant parts tend to unite with the particles of the bodies which they dissolve, is much greater than the force with which these latter are kept united.

Hence, if the parts of the dissolved body be so dense, or be capable of having such contact with the parts of the solvent, that the activity of these latter parts shall be entirely satisfied by their mutual union; the solvent will then be in a state of rest, or in a kind of equilibrium, and will have no more dissolving power. This is called in chemistry the *state or point of saturation*. To make this saturation complete, each of the integrant parts of the solvent must have met an integrant part of the dissolved body, upon which it may exhaust all its activity.

If, on the contrary, the parts of the dissolved body be not sufficiently dense, and cannot have a sufficient contact with the parts of the solvent to satisfy entirely all the tendency of these latter; from such a combination, an imperfect saturation only of the solvent will result, and it will still retain force enough to act upon other bodies. This may be observed in the neutral deliquescent salts, and other combinations of this nature. *See SALTS, and DELIQUESCENCE.*

Fourthly, we may perceive from what has been said, that the force which makes the integrant and constituent parts of bodies tend to each other, although much superior to their gravitation towards the center of the earth, is however limited; that it must be very variable in its effects, and even of no effect in certain circumstances. In the same manner as the adherence of the integrant parts of a body which yields to the action of a solvent, ought not to be considered as any thing in comparison of the force which makes them tend to the parts of this solvent; so that after the solution they cannot any longer be united together, but only to the parts of this solvent; so in the same manner, I say, we may conceive that the force which unites the principles of a compound body to each other ought to become ineffectual, when, on one side, the tendency of the parts of these principles is entirely exhausted by their union; and when, on the other side, to this compound is applied another body, with the parts of which those of one of the principles of the compound may contract an union, infinitely superior to that which they had with the parts of the other principles of the compound. In this case, the principles of the compound must evidently be disunited; one of these principles must form a new compound with the new substance applied to it, and the molecules of the other principles, being now disengaged, must exercise their tendency upon each other, and form small aggregates; which, when they have arrived at a certain mass, must yield to the gravity

gravity by which they tend to the center of the earth. Thus we may conceive how *precipitations* are effected.

This will become clearer by an example; and for this purpose, let us choose a compound, such as that which results from the union of nitrous acid with silver. From experience we know that when copper is applied to this compound, the nitrous acid quits the silver to combine with the copper, with which it forms a new compound; and that silver thus separated from this acid, by the presence and contact of the copper, has no longer any adherence with the acid, unites again into larger molecules, the mass of which becomes so large, that they cannot yield to any other tendency than to the general gravitation which all bodies of a certain mass have towards the center of the earth; and accordingly we see the molecules of silver fall to the bottom of the vessel in which this operation is made. I say, first, that we cannot conceive what happens in this operation, unless we suppose that the force which unites the parts of the silver with those of the nitrous acid vanishes, or becomes ineffectual, in comparison of that force which tends to unite, and which does unite, these parts of the nitrous acid with the parts of the copper. In the second place, supposing always that all chemical combinations and decompositions are the effects of a mutual and particular gravitation of the integrant and constituent parts of bodies to each other, which is in a ratio of the density and contact of these same parts; I say, that if in the present case, the parts of the nitrous acid quit the silver to unite with the copper, the integrant parts of this latter metal must have infinitely more density, or must be capable of having a much more extensive and intimate contact with the parts of the nitrous acid than those of the silver. Whence the action of the parts of the nitrous acid, which is only very imperfectly satisfied by their union with the parts of the silver, is in some measure exhausted by the new union with the parts of the copper; so that only an infinitely small force of adhesion to the parts of the silver remains; and then we may easily conceive that the tendency of the parts of the silver to each other may be more than is sufficient to overcome this slight adhesion; and consequently the parts of silver may really separate from the nitrous acid, and may form sensible masses capable of yielding to the general gravitation to the center of the earth.

Hence also, if, at the same time that the parts of the nitrous acid are determined by the presence and contact of the parts of the copper, to separate from those of the silver, these parts of silver shall find within their reach some other substance, with the parts of which they have a still greater disposition to unite than with each other; they will unite with this substance, and form a new compound; which circumstance ought to facilitate the separation of silver from the nitrous acid; and which also, when the silver has a strong affinity with the matter presented to it, might effect the same decomposition, although even the copper had not a sufficiently strong affinity with the nitrous acid to separate it from the silver. This seems actually to happen in the case of two new decompositions and combinations, which can only be performed by *double affinities*.

All the other phenomena which happen in chemical combinations and decompositions may be easily deduced from the suppositions we have made, and are only the necessary consequences of these suppositions. For these phenomena, we refer to the articles *AFFINITY, AGGREGATION, COMPOSITION, COMBINATION, DECOMPOSITION, SOLUTION, PRECIPITATION, and PRECIPITATES*.

I am

I am sensible that this interesting matter is liable to great difficulties and objections, and is here but superficially treated. Perhaps time, experience, the increase of chemical knowledge, lastly, the zeal of persons skilled in mathematics and chemistry, will hereafter throw much more light upon these subjects, of which now we have but confused notions. However, I cannot but consider them as the true key of the most hidden phenomena of chemistry, and consequently of all natural philosophy.

CCCLVI. GREAT WORK. The great work is the alchemical process by which gold is made, or pretended to be made.

CCCLVII. GRITT-STONE. (s)

CCCLVIII. GUMS. Gums are mucilaginous juices which separate spontaneously from several plants or trees, and which have acquired a solid consistence by the evaporation of the greatest part of their superabundant water. Formerly all concrete juices collected from trees, whatever their nature was, were called gums. Hence many of these juices, which are entirely or partly resinous, are still called gums; such are *gum copal*, *gum elemi*, *gum anime*, *gumma gutta*, and many others: but modern chemists and naturalists have with propriety considered only the concrete mucilages soluble in water as true and pure gums. We shall therefore treat of these gums only in this article.

Gums have a firm and solid consistence, a certain degree of elasticity, and great tenacity of their parts. These latter properties render them capable of resisting percussion without being broken; by which they are rendered very difficultly pulverisable in a mortar. They are more or less white and transparent: some of them, nevertheless, are of a yellow or brown color, but the matters by which they are colored are foreign to them. Very pure gums have no smell, scarcely any taste, or a very mild and slight taste. They are not soluble, either by oils, or by spirit of wine, but are perfectly soluble in water; and when the quantity of water used for this solution is but moderate, they form with it a thick, viscid, transparent fluid, and they again become mucilages, such as they were originally.

Although gums are obtained from many trees and plants of very different kinds, all gums, nevertheless, are very similar, and do not properly differ from each other but by the quantity of mucilage which they are capable of forming with water. Three principal kinds of gums are distinguished. These are *gum tragacanth*, *gum arabic*, and *ordinary gums*.

Gum tragacanth issues from a thorny shrub called *tragacanth*, which grows in Syria and other oriental countries. It consists of small twisted bits, the surfaces of which, when broken, are shining. It contains more mucilage, and is therefore dearer than any other gum.

Gum arabic is obtained from a kind of acacia, and perhaps from several other trees which grow in Arabia and in Africa. It consists of round, rough pieces, some of which are beautiful, white, and transparent.

(s) GRITT-STONE is a stone consisting of particles of sand agglutinated together. The differences of these stones proceed from the different sizes of the particles of sand composing them, the different properties of

these sands, and their different degrees of compactness and of agglutination. Some of these stones are employed for building, others for grinding, others for whetting sharp steel instruments, and others for filtering water.

Ordinary

Ordinary gums are those which are gathered from most fruit-trees; such as almond, apricot, plumb, and cherry trees, &c. It is generally less white and less transparent than gum arabic, though sometimes it is as beautiful. Drug-gifts pick the best pieces of these gums, and sell them for gum arabic; from which no inconvenience proceeds, as they do not essentially differ from that gum.

As gum and mucilage are only one and the same substance united with a greater or less quantity of superabundant water, these matters have absolutely the same properties, and in their analysis furnish the same principles. For a further knowledge, therefore, of the nature of gums, we refer to the article **MUCILAGE**.

**CCCLIX. G U M - R E S I N S.** Gum-resins are juices, partly mucilaginous and partly oily, which flow from many kinds of trees, and which become concrete by the evaporation of their finest fluid parts.

The oily and mucilaginous parts which form gum-resins are intimately mixed, but not absolutely combined with each other: hence these concrete substances are not perfectly soluble, either by water, by oils, or by spirit of wine, singly. When indeed any of these solvents, for example, water, is applied singly to most gum-resins, and when the action of such solvent is assisted by trituration, a kind of solution is effected. The gummy part is entirely soluble in water, and forms a mucilage with it; while the resinous part, which was originally much divided and intimately mixed with the gummy part, remains suspended in the water, and consequently forms a kind of milk or emulsion: but this oily part is then evidently divided only, but not dissolved. See **EMULSION**. Thus the gum-resin is reduced nearly to its original state; I say, nearly, because the oily substance loses by drying its most fluid and volatile part, which is not restored to it by treating it with water in the manner above-mentioned.

We may also make a kind of solution of these gum-resins, by employing solvents, which are partly watery, and partly oily or spirituous; such as wine, vinegar, or aqua vitæ; but these solutions are always milky, from the water which hinders the spirituous part from combining intimately with the resin. To dissolve, therefore, completely a gum-resin, the resinous part must be separated from the gummy part, by applying alternately a spirituous menstruum, and a watery menstruum.

From these properties of gum-resins, relating to their solubility, chemists have discovered their true nature; for from most of their other properties, and particularly from their external appearance, they might be confounded with pure resins, to which they have a strong resemblance. Here we ought to remark, that the proportion of the gum and of the resin is not constantly the same in different gum-resins, in some of which the gummy part is very small in proportion to the resinous: hence, upon a more particular examination of the concrete juices which issue from trees, many of them are classed among the gum-resins, which formerly had been considered as pure resins; and this subject is still very uncertain. Nevertheless, as all gum-resins are mixtures of substances which are not mutually soluble by each other; and as from such a mixture the compound bodies which result must be opaque; we may discover, merely by the view, whether any concrete juice be a gum-resin or not. All those which are opaque, or are not evidently transparent, may reasonably be suspected to be of a gummy-resinous, or extractive resinous nature. Of this kind are

*myrrb*, *bdellium*, *sagapenum*, *opoponax*, *assa-fetida*, and others which are evidently gum-resins. On the contrary, all those which are very transparent may be certainly considered either as pure gums or pure resins: such are the gums *tragacanth* and *arabic*; and the pure resins *masitic*, *sandarac*, *gum-copal*, and other diaphanous substances, which may be discovered to be pure resins, and distinguished from pure gums, by their smell, inflammability, and other qualities peculiar to oily matters.

This rule, which certainly may be useful in determining without trouble concerning the nature of concrete juices, ought not to prevent us from making other suitable trials, and particularly those by applying different menstruums, when we would certainly determine the nature of the matter to be examined. These trials are particularly necessary for those concrete juices which are but little transparent, and are strongly colored. Such are *gum-lac*, *gumma gutta*, *sanguis draconis*, *aloes*, *opium*: for these latter concrete juices are still more compounded than pure gum-resins, and contain different coloring and extractive matters. See OILS, MUCILAGE, EXTRACTS, EMULSIONS, GUMS, and RESINS.

CCCLX. G U N - P O W D E R. See POWDER.

CCCLXI. G U Y A C. Guyac is a very hard, heavy, compact wood of a tree which grows in hot countries, particularly in the Antilles Islands, and in other parts of America. It contains much resin, which may be extracted from it by spirit of wine, in the same manner as the resins of jalap, turpentine, &c. may be extracted from the vegetables which contain them. See ANALYSIS by MENSTRUUMS, and RESINS.

Guyac wood, when distilled with a heat not exceeding that of boiling water, is not, properly speaking, decomposed; since nothing passes over but a pure, or almost pure, phlegm, which seems to be nothing else than the superabundant water it contains: a naked fire, therefore, is necessary for the decomposition of this and all other woods. When guyac is to be distilled, it is to be cut into thin shavings, and put into a stone-ware retort; to which is to be adapted a large glass receiver with a small hole pierced in its side; and the distillation is to be promoted by a graduated fire. At first, a liquor almost purely watery is obtained; and then, upon encreasing the fire, an acid, reddish, empyreumatic liquor passes over, together with a little fluid reddish oil. These results rise in white vapors, and, at the same time, a considerable quantity of air is disengaged, which would burst the receiver, if it was not allowed to escape through the small hole, which is sometimes opened for that purpose. The acid and oil continue to rise thus to the end of the distillation; the acid becoming stronger and stronger, and the oil becoming more and more empyreumatic, black, and thick: so that, at last, its consistence is equal to that of turpentine. Lastly, when the retort is thoroughly red-hot, the distillation is finished. In the retort, the shavings of guyac are found reduced to perfect coal; but still retain their original form. The acid, called also the *spirit*, and the oil are found together in the receiver, and may be separated from each other by a funnel.

This analysis of guyac is well known by chemists, because the empyreumatic oil produced was one of the first which was observed to be capable of inflammation by mixture with spirit of nitre; and because this analysis is generally given as an example of the distillation of vegetables with a naked fire.

Thus,

Thus, for instance, all the odoriferous plants from which the spiritus rector, essential oil, and other volatile principles, have been extracted by a degree of heat not exceeding that of boiling water, being afterwards distilled with a naked fire, without which they cannot be decomposed, yield principles analogous to those obtained from guyac wood.

The analysis of guyac wood exhibits some phenomena deserving attention. The great quantity of air disengaged during this operation is very remarkable. It proves that this element is truly combined in certain bodies, and particularly in this; that is to say, that its integrant parts are disunited from each other, and adhere to some of the united parts of the guyac. This is proved by the long time during which the air disengages itself from the guyac; for this element being much more volatile than water, if it was not combined and retained by some fixed principle to which it is united, it would be soon disengaged, and with a heat much less than that which is sufficient to raise the superabundant and uncombined water of the guyac. Besides, this air seems to be deprived of its elasticity while it remains in this compound; otherwise, it could not be condensed into so small a space, but by a violent compression. But this privation of the elasticity of the air proves also that its aggregation is broken, in the same manner as the phlogiston, or combined fire, has neither light, heat, nor fluidity, which are properties essential to it, when it is in its state of aggregation.

The acid obtained in distillation with a naked fire from guyac and other similar vegetables is still united, and even intimately, with a considerable portion of oil. This appears from its color, and particularly from its empyreumatic smell; for this smell cannot be contracted by any thing but oil: besides, the acid may be deprived of much of this empyreumatic oil, by further operations, and particularly by saturating it with alkalis, from which it may be afterwards separated by a second distillation. In both these operations much of the oil is separated, and thus the acid is rectified.

This portion of empyreumatic oil is found to be well combined with the acid after the first distillation; for it no longer disturbs its transparency, even when it is mixed with much water; because the acid serves as an intermediate substance to keep the oil and water suspended or dissolved.

This rectification of empyreumatic vegetable acids has not been carried so far by chemists, as it might be.

The oil obtained in this distillation is acrid and empyreumatic, it being one of those which are incapable of being distilled but by a heat much superior to that of boiling water, by which heat all oils are much altered, acquire a burnt and empyreumatic smell, and allow much of their acid to escape. See OIL. The oil of guyac is employed, as all those equally acrid, to facilitate the exfoliation of carious bones.

Lastly, the coal found in the retort is a perfect coal, when the distillation has been continued till the retort has been red-hot; otherwise the residuum would contain some thick and half-burnt oil; but it is contrary to the nature of coal to contain any oil. See COAL.

CCCLXII. G U H R. (1)

(1) G U H R, *Creta fluida*, *Medulla fluida*, liquid calcareous or chalky substance, white *Marga fluida*. Those names are given to a or ash-colored, found generally in mines and subterranean



**CCCLXIII. G Y P S U M.** Gypsum is a soft, friable, stony matter, which does not strike fire with steel. It is found in large quantities in many parts of the earth, forming large mountains, and very extensive chains of mountains and hills, as in the neighbourhood of Paris.

Gypsum is always crystallized, or regularly disposed. In its crystallization it affects several different forms. The first form is that of large, transparent, shining, thin laminæ applied to each other, so exactly, that they constitute masses as transparent as crystal. These are called by naturalists, *lapis specularis*, from their large shining surfaces, like those of mirrors.

In the second place, a large quantity of gypsum is found crystallized in striæ, like threads applied longitudinally to each other. This is called *striated gypsum*. Lastly, a very large quantity of gypsum is found in small irregular crystals, agglutinated to each other, forming considerable masses of semi-transparent granulated stones, commonly called *gypseous alabaster*, when they are very white and pure, which gives them a more beautiful and perfect semi-transparency. See **ALABASTER.** (u)

All these gypsums, although very different in external appearance, are perfectly similar as to their chemical and essential properties.

When exposed to a very moderate heat, they quickly lose their transparency, and acquire an opaque white color. They also become very friable by exposure to this heat, and the laminæ of the *lapis specularis* separate from each other.

Gypsum in this state, mixed and kneaded with water, forms a kind of mortar, which soon hardens into a solid body. This property renders it very useful for buildings, in the construction of which it is employed under the name of *plaster*. And, in fact, nothing can be more convenient than a stone which in its soft state is capable of receiving any form, which it afterwards preserves many years by its property of hardening.

The properties above-mentioned are peculiar to gypseous matters, and distinguish them from *talcs*, *amianthus*, *asbestos*, with which they frequently have an external resemblance.

Gypsum by other properties resembles calcareous earths. Thus, when it is calcined and put into water, a pellicle like the cream of lime is formed upon the surface of the water. This water makes the syrup of violets green, as lime-water does. Lastly, gypsum acts a little upon sulphur, and makes it a kind of earthy hepar of sulphur, as quicklime does: but, nevertheless, gypseous and calcareous stones ought not to be confounded together.

Gypsum differs from calcareous earth in this, that it does not dissolve and effervesce with acids. Mr. Pott observes, that vitriolic and nitrous acids being treated with gypsum, do not lose their acidity; whereas these acids are easily

subterranean places, where it drops and forms stalactitical concretions. There are also *metallic guhrs*, or liquid masses, sometimes found in mines, containing metallic particles; and which, by dropping, form metallic stalactitical concretions.

(u) Besides the gypsums above-mentioned, a rhomboidal gypseous stone is found,

called also *selonites*, sometimes laminated, and sometimes not. It is distinguishable from rhomboidal calcareous spars by the general properties of gypseous earths, and by its truncated angles. Other gypsums are found, consisting of differently formed crystals, as hexagonal parallelepipeds and pyramids.

neutralised



neutralised by calcareous earth, with which they form neutral salts with earthy bases. Mr. Beaumé remarks, that gypsum may indeed be dissolved in some measure by acids; but that the gypsum thus dissolved is afterwards separated by crystallization, and is in the same state as it was before that solution, without retaining any part of the acids. Besides, quicklime does not harden, as gypsum does, without addition of sand or cement.

These differences are sufficient to distinguish gypseous from calcareous earths. But this distinction is further established by experiments which have been lately made by chemists to determine the nature of gypsum.

Mr. Pott, in his *Lithogeognosia*, places gypsum amongst the four principal kinds of earths, to which he refers all the others, and consequently distinguishes it very accurately from the three other principal earths, and particularly from calcareous earth. He relates in that work many experiments made upon gypsum, to shew its nature and properties. Gypsum, according to him, cannot be fused without addition by the most violent fire of furnaces. Some chemists had affirmed that it was fusible by the heat of solar rays collected by mirrors. Mr. Pott did not repeat that experiment.

I have exposed lapis specularis to the focus of a good burning mirror; and I remarked, that while the focus of rays fell upon its flat surface, the stone was only calcined, and not fused; but that when the focus was applied to the side of the stone formed by the edges of the plates or laminæ placed upon each other, this gypsum was immediately fused with a considerable ebullition. (\*)

From Mr. Pott's experiments we chiefly learn, that gypsum or gypseous alabaster, (for that was the kind which he made the subject of his experiments) may be fused and vitrified when mixed with argillaceous earths, to which it serves as a flux, as calcareous earth does: but in this fusion with argillaceous earth, gypsum bubbles and swells much more than pure calcareous earth does.

This fusion of clay procured by gypsum, as by calcareous earth, as well as the other properties common to gypsum and calcareous earth, are occasioned by the greatest part of the gypsum being really composed of calcareous earth, which earth has been proved to be united in this compound with vitriolic acid. Mr. Macquer, in his *Memoir upon Quicklime and Plaster*, printed amongst the *Memoirs of the Academy* for the year 1747, mentions the vitriolic acid as one of the constituent parts of gypsum.

Mr. Pott, in his *Lithogeognosia*, says, that several Authors rank amongst gypsums a composition resulting from the union of vitriolic acid with a calcareous earth; and that they call this compound *selenitic earth*, or *artificial gypsum*. Although Mr. Pott found some slight differences betwixt this compound and natural gypsum, yet the former had all the essential properties of the latter.

Mr. Macquer, treating of hard waters, in his *Elements of Chemistry*, says, that their hardness is occasioned by a gypseous selenites which is dissolved in

(\*) From Mr. D'Arcet's *Memoir upon the Effects of violent and long-continued Heat*, we find that all gypseous stones and earths are fusible by the fire of furnaces. This, however, we may observe concerning the fusibility of gypsum, that if it be exposed long

to a moderate fire not sufficient to fuse it, much of its vitriolic acid will be expelled, and part of it will be reduced to a calcareous earth, as unfusible as chalk, or the other earths of that kind; therefore, a violent heat suddenly applied is necessary to the fusion of gypsum.  
them..

them. Lastly, Mr. Margraaf says, that from gypsum distilled with powder of charcoal he obtained a volatile sulphureous acid and true sulphur; that having treated it with the alkali of tartar, by the dry and by the humid way, he obtained from it a vitriolated tartar; that the remaining earth was calcareous; that gypsum is entirely soluble in water; and that it may be artificially composed by saturating vitriolic acid with calcareous earth. *Opusc. Chem. 13 Diff*

We may then consider, that gypsum has been demonstrated to be nothing else than calcareous earth saturated with vitriolic acid. It is a vitriolic salt with basis of calcareous earth; that is, it is a true *selenites*. See *SELENITES*

From this account we may explain all the properties of gypsum. Its want of hardness, its transparency, its crystallization, its solubility in water, proceed from its saline character. It cannot be combined with any acid, because it is naturally saturated with the vitriolic acid. It requires much water to dissolve it, which proceeds from its selenitic quality; that is, from the great quantity of earth which it contains, and the intimacy with which this earth is united with the vitriolic acid. Its calcination, by which the cohesion of its parts are destroyed, is nothing else than the subtraction of the water of its crystallization. See *CRYSTALLIZATION*.

The properties of quicklime which gypsum acquires by calcination, ought also to be attributed either to the superabundant calcareous earth which it may contain or rather to the subtraction of a portion of the vitriolic acid, which is disengaged during the calcination, chiefly by touching some inflammable matters, with which this acid unites and forms sulphur. Lastly, the hardening of plaster, when calcined and mixed with water, may proceed from a mixture of those parts, which by calcination have become quicklime, with those other parts which have not acquired that quality, and which serve to the former as a cement, as Mr. Macquer conjectures in the above quoted memoir (See *QUICKLIME*): or else this hardening proceeds from the gypsum resuming the water of its crystallization, and again crystallizing precipitately and confusedly, as many chemists think, and particularly Mr. Pott, who says, "As plaster mixed with water does not harden, but when it is left at rest, (for if it be stirred too long, it will not become hard) we ought to conclude, that in this case a crystallization very suddenly happens, which consequently supposes a very divided saline substance, uniformly diffused through the plaster, as Stahl has observed. 'This also is the reason of the want of durability of plaster in the air; because the air alters and attacks the saline substance which it contains.'"

Some chemists and naturalists have given to gypsum the name of *spar*, or rather distinguish a kind of spar by the appellation, *gypseous*; because this spar has the principal properties of gypsum. See *SPAR*.

## H.

CCCLXIV. **HARDNESS.** Hardness is a quality of certain bodies which consists in an intimate union and strong adhesion of their integrant parts, which cannot therefore be easily disjoined.

We cannot precisely determine what disposition of parts occasions the greatest hardness: but this probably depends on the perfection and extent of the contact of these parts; and this quality depends essentially upon their figure, which we do not know.

The hardest bodies which we know are vitrifiable stones; and amongst these, the hardest are those which are the most pure and homogeneous; that is, diamonds.

Not any one of all known bodies is perfectly hard. Perfect hardness belongs undoubtedly to the primary, elementary, and constituent parts of matter, which of all beings we know the least of.

CCCLXV. **HELLEBORE.** (y)

CCCLXVI. **HEMATITES.** (z)

(y) **HELLEBORE.** Two ounces of the root of *white hellebore* yielded, with water, nine drams and a scruple of gummy extract; and the same quantity of root yielded with spirit of wine seven drams of resinous extract. From six ounces of the root of *black hellebore*, six drams and a scruple were extracted by spirit; and from the same quantity of root six drams and two grains were extracted by water. Borrichius relates, that the distilled water of the whole plant possesses emetic and purgative qualities.

(z) **HEMATITES**, or *Bloodstone*, is a hard mineral substance, red, black, or purple;

but the powder of which is always red; sometimes of an intermediate figure, and sometimes spherical, semi-spherical, pyramidal, or cellular, that is, like a honey-comb; consisting of pyramids generally small, the apices of which appear, in a transverse section, in the center. It contains a large portion of iron. Forty pounds of this metal have been extracted from a quintal of the stone. But the iron is obtained with such difficulty, and is of so bad a quality, that this ore is not commonly smelted. The great hardness of hematites renders it fit for burnishing and polishing metals.

CCCLXVII.

CCCLXVII. H E P A R. (a)

CCCLXVIII. H E T E R O G E N E O U S, and H O M O G E N E O U S. Heterogeneous signifies of different natures; and homogeneous signifies of the same nature.

CCCLXIX. H O P S. (b)

CCCLXX. H Y D R O M E L. Hydromel is honey diluted in nearly an equal weight of water. When this liquor has not fermented, it is called *simple hydromel*; and when it has undergone the spirituous fermentation, it is called the *vinous hydromel*, or *mead*.

Honey, like all saccharine substances, vegetable or animal, is susceptible of fermentation in general, and particularly of the spirituous fermentation. To induce this fermentation, nothing is necessary but to dilute it sufficiently in water, and to leave this liquor exposed to a convenient degree of heat. To make good vinous hydromel, or mead, the whitest, purest, and best-tasted honey must be chosen, and this must be put into a kettle with more than its weight of water; a part of this liquor must be evaporated by boiling, and the liquor scummed, till its consistence is such, that a fresh egg shall be supported upon its surface without sinking more than half its thickness into the liquor; then the liquor is to be strained, and poured through a funnel into a barrel: this barrel, which ought to be nearly full, must be exposed to a heat as equable as is possible, from 20 to 27 or 28 degrees of Mr. Reaumur's thermometer, taking care that the bung-hole be slightly covered but not closed. The phenomena of the spirituous fermentation will appear in this liquor, and will subsist during two or three months, according to the degree of heat; after which they will diminish and cease. During this fermentation, the barrel must be filled up occasionally with more of the same kind of liquor of honey, some of which ought to be kept apart on purpose to replace the liquor which flows out of the barrel in froth. When the fermentation ceases, and the liquor has become very vinous, the barrel is then to be put in a cellar and well closed. A year afterwards the mead will be fit to be put into bottles.

The vinous hydromel or mead is an agreeable kind of wine; nevertheless it retains long a taste of honey, which is displeasing to some persons; but this taste it is said to lose entirely by being kept a very long time.

The spirituous fermentation of honey, as also that of sugar, and of the must of vinous liquors, when it is very saccharine, is generally more difficultly effected, requires more heat, continues longer, than that of ordinary wines made from the juice of grapes; and these vinous liquors always preserve a saccharine taste, which shews that a part only of them is become spirituous. The cause of this probably is, that they contain less acid, or that they contain an acid less disengaged than the must of ordinary wine. See FERMENTATION and WINE.

(a) H E P A R. See L I V E R.

(b) Hops are usually added to malt liquors, and are said to render these liquors less apt to become sour, less viscid, and more wholesome by their aromatic bitter-

ness. They contain a subtle-odorous principle, which promotes the vinous fermentation. When infused, or but slightly boiled in wort, they encrease its spirituousity. *Neuman.*

**CCCLXXI. H O N E Y.** Honey is a saccharine fermentable juice collected by bees from flowers. *For the nature and properties of honey see SUGAR.*

**CCCLXXII. H O R N of A N I M A L S.** The horn of animals is of the same nature as their gelatinous matter, and is only that matter charged with a less quantity of water, with a larger quantity of earth, and sufficiently condensed to have a firm and solid consistence. By digesting horn with water in Papin's digester, it may be entirely converted into jelly.

Horn is a perfectly animalised matter, and furnishes in distillation the same principles as all animal matters; that is, at first a pure phlegm, with a degree of heat not exceeding that of boiling water; then a volatile alkaline spirit, which becomes more and more penetrating and strong; a fetid, light, and thin oil; a concrete volatile salt, which forms ramifications upon the sides of the receiver; much air; fetid oil, which becomes more and more black and thick; and lastly, it leaves in the retort a considerable quantity of almost incombustible coal, from which, after its incineration, scarcely any fixed alkali can be obtained.

Animal oil, and particularly that which is drawn first in the distillation of horn, is susceptible of acquiring great thinness and volatility by repeated distillations, and is then called *the oil of Dippel*. See that article.

The horns of stags, and of other animals of that kind, are the most proper to furnish the animal oil to be rectified in the manner of Dippel; because they yield the largest quantity. These horns also differ from the horns of other animals in this, that they contain a larger quantity of the same kind of earth which is in bones; hence they seem to possess an intermediate nature betwixt horns and bones.

**CCCLXXIII. H O R N (H A R T ' S ) C A L C I N E D to W H I T E - N E S S.** The phlogiston of the coal of hart's-horn, although very difficultly combustible, may nevertheless be burnt with more ease than the coal of other horns, and with nearly the same facility as bones may. This coal, by being calcined with a long-continued and strong fire, is changed into a very white earth called *hart's horn calcined to whiteness*. This earth is employed in medicine as an absorbent. It is given in dysenteries and labor-pains which are supposed to be caused by acrid and ill-digested matters. Hart's-horn calcined to whiteness and levigated is the basis of Sydenham's *white decoction*, which is commonly prescribed in these diseases.

**CCCLXXIV. H O R N (H A R T ' S ) P R E P A R E D P H I L O S O P H I C A L L Y.** This name is given to hart's-horn deprived by water of almost all its gelatinous part; so that it becomes brittle; and when its outer part is taken off, it is thus rendered very white, and is applicable to the same uses as that which is calcined by fire.

**CCCLXXV. H O R N - B L E N D. (c)**

(c) **HORN-BLEND** is a black or green indurated bole or clay, consisting of scaly particles, which are distinguishable from those of mica, by being less shining, thicker, and rectangular. It is generally found amongst iron ores, and sometimes intermixed with mica, forming a compact stone.

CCCLXXVI. HORNSTEIN. (d)

CCCLXXVII. HYACINTH. (e)

(d) HORNSTEIN, *Petrofili Wallerii*. This name is given by German authors to the filiceous stone called in England chertz. See CHERTZ.

(e) HYACINTH, or JACINTH, is a pre-

cious stone, polygonal, more or less transparent, of a yellowish red color, the ninth in degree of hardness from diamonds, and fusible by fire.

CCCLXXVIII.

## I.

CCCLXXVIII. JACINTH. See HYACINTH.

CCCLXXIX. JALAP. (f).

CCCLXXX. JAPONIC EARTHS. (g).

CCCLXXXI. JASPER. (b).

CCCLXXXII. ICHTHYOCOLLA. See ISINGLASS.

CCCLXXXIII. JELLY. From many vegetables, mucous substances capable of forming kinds of jelly are obtained, but these are more frequently called *mucilages* and *gums*. The name *jelly* or *gelatinous matter* is particularly applicable to the mucous substance obtained from animals.

The bodies of most animals seem to be chiefly composed of gelatinous matter. For if we boil in water, flesh, bones, membranes, tendons, nerves, horns, skin, in a word, any of the several solid or soft parts which compose animal bodies, and if we evaporate sufficiently this water, the liquor by cooling will become a true jelly. If the evaporation be continued till the matter be dry, but with a heat incapable of decomposing this jelly, it forms at first a glue, and afterwards a horny substance more or less transparent, hard and solid.

(f) JALAP. From sixteen ounces of root of jalap, spirit of wine extracted five ounces, and four scruples of resinous matter; and from the residuum, water extracted two ounces and a half of gummy-matter. This root is observed to have a considerable power in promoting the spirituous fermentation of sweet vegetable juices, as of melasses. *Neuman*.

(g) JAPAN-EARTH. This name is improperly given to a gum-resin, obtained by inspissating the juices or decoction of the fruit of a certain palm-tree, which grows in the East Indies. It is almost entirely soluble, when pure, by water, or by spirit of wine. Its taste is at first bitterish and styptic, and is afterwards agreeably sweet. *Neuman*. The Indians are said to cut the fruit of this tree into small pieces, which they wrap in the

leaves of the maritime plant *betel*, together with some quicklime, and to chew these balls, the taste and smell of which they find to be very agreeable.

(b) JASPER is an opake siliceous stone, of various colors, white, green, red, yellow, black, or variegated with spots or with veins of different colors. It differs from flints and chert, in being opake, in being more easily fusible by fire, in having a granulated texture, and in frequently composing large masses, or rocks; whereas flints and chert are generally in form of nodules or lumps. From some jaspers, iron may be obtained. They are sufficiently hard and compact to receive and retain a fine polish.

When jaspers are spotted with specks of onyxes or agates, they are called *jaspomyxes*.

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great difficulty. From the ashes of this coal an exceeding small quantity of fixed alkali, and a little common salt may generally be obtained. These are exactly the same substances which may be obtained from all animal matters. As many things are common to jelly and to vegetable mucilage, *see the word* MUCILAGE.

CCCLXXXIV. JET.<sup>a</sup> (i).

CCCLXXXV. INDIGO. (k).

CCCLXXXVI. INFLAMMATION of OILS by NITROUS ACID. The vivid inflammation occasioned by mixing highly concentrated nitrous acid with most oils, is one of those surprising phenomena, which excite the admiration even of people the most unintelligent, and least conversant in matters of chemistry and experimental philosophy. No wonder, therefore, that it has particularly excited the attention of chemists. Glauber, Borrichius, Tournefort, Homberg, Rouviere, Dippel, Hoffman, Geoffroy, and Mr. Ronelle, have particularly applied themselves to this matter. These chemists have successively found methods of inflaming different oils, and have published their processes in their writings.

Borrichius, a Danish chemist, had affirmed in the Copenhagen Transactions for the Year 1671, that oil of turpentine may be inflamed by mixing it with nitrous acid. But as in that time a highly concentrated nitrous acid was very rare, most of the chemists who attempted to repeat this experiment, did not succeed. Tournefort, in the year 1700, inflamed by this method the oil of saffras. Homberg in the year 1701 says, in the Memoirs of the Academy, that he inflamed oil of turpentine by mixing it with nitrous acid; but he says

(i) *JET*, *Gagates*, *Succinum nigrum*, is a black bitumen, resembling fine black ebony wood, hard, light, compact, and smooth. It is very inflammable, and burns with a bituminous smell. By distillation it yields, 1. an acid liquor; 2. a thin black oil; 3. a thick black oil. By friction it becomes electrical, as amber does. *See BITUMEN*.

(k) *INDIGO* is a blue fecula, obtained from the American plant and by means of fermentation, in the following manner. The herb is put into a vat and covered with water. In a few hours the liquor begins to ferment, becomes hot, throws up a froth, and acquires a blue or violet color. The liquor is then emptied into another vat by means of a cock inserted near the bottom of the first vat. In the second vat, the liquor is to be continually and strongly agitated by sticks and buckets annexed to sticks, by which means the blue coloring matter is made to unite together, or is disposed to separate from the liquor, and to subside. When the blue matter has subsided, the water is let off by cocks, and the sediment, when drained and dried in the air, is indigo.

Indigo may be almost entirely consumed by fire. With water it may be formed into a paste, diffusible through more water; but at last the coloring matter subsides. By means of fixed alkaline salt it becomes permanently diffusible in water. Woolen stuffs previously steeped in warm water, being dipped in the above liquor, are dyed of a green color, which is almost instantly, by exposure to air, changed to a fine blue. Volatile alkaline spirits extract yellowish or brownish red tinctures, and spirit of wine a reddish tincture; by digestion with indigo. Indigo gives no color to lime-water, or to water acidulated with vitriolic, nitrous, or marine acids. The concentrated vitriolic acid unites with indigo into a smooth paste, especially if the indigo be previously ground with powdered glass, or sand. By this method, the indigo is rendered soluble in boiling water along with the acid, so as to pass through a filter. This solution, when hot, is of a bright green color, and, when cold, becomes brown. The above experiments are mentioned by Dr. Lewis in a note to his translation of Neuman's Works.

that

that the oil must be thick. Rouviere, in the year 1706, inflamed the empyreumatic oil of guyac, and his experiment was much talked of, because it succeeded more easily than the others, because this inflammation is very vivid, and because it is attended by a surprizing circumstance, namely, that from amidst the flames arises a black, thin, spongy body, of a considerable height, which is, as we shall see, only the thickest part of the oil rarefied and burnt during the inflammation. This inflammation of oil of guyac was solely attended to, and was shewn to students in courses of chemistry and experimental philosophy; till Hoffman, a German chemist, and Geoffroy, a French chemist, having made many experiments on this matter, discovered at the same time, that smoking nitrous acid mixed with concentrated vitriolic acid, succeeded infinitely better for the inflammation of oils, and particularly of the oil of turpentine, which had been almost relinquished. Mr. Rouelle then resumed this subject, and published in the year 1747, a Memoir filled with many experiments, which shewed, that by nitrous acid may be inflamed all essential oils, including oil of turpentine, and even those sweet expressed oils which are capable of quickly thickening and drying, such as oils of nuts, linseed, hemp, provided that the acid be sufficiently concentrated. Lastly, the same chemist discovered that even the sweet oils least disposed to dry, that is, those called *fat oils*, may also be inflamed. But to make their inflammation succeed, the method mentioned by Hoffman and Geoffroy was necessary; that is to say, some concentrated vitriolic acid must be previously mixed with the nitrous acid. As these last mentioned oils are of all oils the least inflammable, we have reason to believe that every oil may be inflamed by a mixture of these two acids.

Mr. Rouelle further remarks, in the above quoted Memoir, that flame is more certainly produced in all these experiments, when the nitrous acid is poured on at intervals, and when it is applied to that part of the oil which the portions of acid first poured on had thickened, heated, and dried. The inflammation of oils by acids is now become an experiment easily performed. The following circumstances are remarked to be peculiar to the inflammation of the several kinds of oil.

All essential oils, and even the sweet drying oils, may be inflamed by the nitrous acid alone, provided that the vessel in which the inflammation is to be made be of a convenient size and form, that the nitrous acid be sufficiently concentrated, and that a sufficient quantity of acid and oil be employed. The vessel ought to be sufficiently wide-mouthed; and the nitrous acid, for greater certainty, ought to be so concentrated that a phial capable of containing exactly an ounce of pure water, shall be capable of containing one ounce four gros and two scruples of this acid. Lastly, an ounce of this acid, and as much of the oil to be inflamed, ought to be employed, although less quantities may succeed, but less certainly. The oil is first put into the vessel in which the inflammation is intended to be. Then the vessel containing the nitrous acid is to be tied to one end of a rod, that the operator may not be hurt by the part of the mixture which is generally thrown out of the vessel, and sometimes at a considerable distance. One half or two-thirds of the acid is poured at once. A considerable ebullition is excited by the reaction of these two liquors. The oil becomes black, thick, and sometimes inflames. If it does not inflame within

within four or five seconds, more nitrous acid must be poured upon the part which appears thickest and driest, and then the mixture never fails to be inflamed.

The oils of almonds, olives, rapeseed, and other fat oils, have not been hitherto inflamed by the nitrous acid alone. But their inflammation is effected, as Mr. Rouelle practises, by mixing with them first equal quantities of the concentrated vitriolic and nitrous acids, which occasion less quick and violent ebullition than in the preceding instances; but when this ebullition is at its height, some pure nitrous acid must be poured on the thickest part of the mixture. Then the inflammation generally happens, but is less strong than when any other kind of oil is used.

Although these phenomena be surprising, their theory is easy. All oils contain phlogiston as a constituent part. Nitrous acid also contains phlogiston. Hence we may understand the cause of the powerful action of these two substances upon each other. The heat resulting from their reaction is equal to that of ignition; and hence the oil and even the nitrous acid being capable of inflammation, must consequently be inflamed.

The reaction becomes more strong, and the inflammation more certain, when the nitrous acid is applied to the part of the oil which has already been thickened and dried, either by the nitrous acid alone, or by that acid mixed with vitriolic acid. But ought this portion of thickened and dephlegmated oil to be considered as a pure coal? And ought the action of the disengaged nitrous acid upon this thickened oil, to be compared to the action of nitre detonating with coal? We cannot be easily persuaded of this, when we consider that nitrous acid, however much concentrated, when not retained by some base, has no action upon any kind of coal, even when heated as much as possible. See DETONATION OF NITRE.

The effect produced by the addition of the vitriolic acid, may be explained in the following manner. This acid does much promote these inflammations; since, on the one hand, it makes them succeed more certainly, and with less doses than can be done with the nitrous acid alone; and on the other hand, some oils have never hitherto been made capable of inflammation without it. But although this acid acts powerfully upon oils, it cannot singly inflame any of them. Mr. Rouelle considering, that as the vitriolic acid is essentially stronger, and has a greater affinity to water than nitrous acid, believes that it renders the nitrous acid more capable of inflaming oils by dephlegmating it. Probably the vitriolic acid may from this cause facilitate the inflammation of oils; but has it not also as great an affinity with the water contained in the oils, as with that contained in the nitrous acid? and may not, consequently, its power of facilitating these inflammations proceed from the dephlegmation of the oils; as well as of the nitrous acid?

**COGLEXXXVII. INFUSION.** Infusion, taken in its most general sense, consists in placing compound bodies in a liquor intended to be impregnated with some of their principles, either without heat, or with a heat less than that of the boiling liquor.

From this definition we may see that infusion is one of the principal operations of the analysis by menstrua, in the same manner as decoction is, of which infusion may be considered as the first degree.

Infusion

Infusion may be made in watery, spirituous, oily, acid, or alkaline liquors, according to the nature of the matters to be infused, and of the principles intended to be extracted. It is nevertheless practised upon vegetable matters only, and almost always for the preparation of remedies which are also called *infusions*.

Aromatic plants and other odoriferous vegetable matters are generally infused when their odoriferous principle is to be preserved, in which their virtue consists; and which is at the same time so volatile as to be dissipated and lost by the heat of ebullition. To preserve still better these volatile principles, the smallest heat requisite for the extraction ought to be employed; and these infusions ought to be made in matrasces or other vessels, which may be exactly closed.

The principles extracted by infusion are different according to the menstruum employed.

Pure water may be impregnated with the odoriferous principle, or spiritus rector, with saline, saponaceous, mucilaginous, extractive principles. Spirit of wine dissolves the spiritus rector, the essential oils, those resinous matters the base of which is an oil of the nature of essential oils, and greatest part of the saponaceous extractive matter. Those infusions made by spirit of wine are particularly called *tincturas*, especially in pharmacy. Oils dissolve the spiritus rector, and any oily matter. Acids and alkalis dissolve the earthy substances of vegetables, and almost all their other principles: but they disguise them, alter them, and change considerably their virtues by the combination. They are therefore not much used for these kinds of extractions. See ANALYSIS, DECOCTION, EXTRACTS.

CCCLXXXVIII. I N K. Ink is a liquor, generally black, used for writing. Nevertheless some inks are of other colors.

The basis of black ink is an infusion of galls, and of martial vitriol, known to druggists by the name of green copperas; both which are mixed together, and to them is added some gum-arabic. The following receipt makes good ink: In four pints of common water or beer, let a pound of bruised galls be infused twenty-four hours without boiling; to this add six ounces of gum-arabic; and when the gum is dissolved, six ounces of green vitriol, which will soon give it the black color: the liquor is then to be strained through a hair sieve.

Galls and all vegetable astringents have the property of separating iron, when it is united, either with vitriolic acid, or with any other acid; and the precipitate thus formed is black. The blackness of these precipitates is caused by a certain quantity of oily matter which they receive from the vegetable substances.

In the operation of making ink, something passes analogous to the precipitation of iron into Prussian blue, by means of a phlogisticated alkali. Some chemists having even remarked that ink diluted with much water has a color approaching to blue, have considered the martial precipitate of ink as a Prussian blue, the color of which is so intense as to seem black when diluted in a small quantity of water; because a very deep blue has actually the appearance of a black: but this opinion does not correspond with the properties of ink or of Prussian blue. Iron precipitated in these two methods is essentially different; and the difference proceeds from the different natures of the two inflammable matters

matters with which the iron unites itself in these two cases. The inflammable matter which unites with iron in the preparation of ink is in an oily state; and that in the preparation of Prussian blue is not in that state. See BLUE (PRUSSIAN). Accordingly the precipitate of iron in ink is easily soluble by all acids; but the precipitate of Prussian blue is not. If a sufficient quantity of spirit of nitre, or any other strong acid, be mixed with ink, its color will disappear, and the blackest ink will thus be rendered clear and transparent as water. Its blackness and opacity may be again restored to it by adding to the ink thus discolored a sufficient quantity of alkali to saturate all the acid which had dissolved the martial precipitate; by which means this precipitate resumes its former appearance. Thus the black color of ink may be made to disappear and appear again as often as we please, by mixing with it alternately some acid and some alkali: but this change of color cannot be produced upon the Prussian blue. By adding any quantity of an acid to the water in which Prussian blue is suspended, its color, so far from being altered, becomes only the more beautiful by that addition.

The color of Prussian blue may be indeed made to appear and disappear at pleasure by one method: but this method is precisely the reverse of that used to produce those effects upon ink. By mixing much alkali with Prussian blue, its color is destroyed; and by saturating this alkali with an acid, the color is restored. This constitutes a very sensible difference betwixt these two martial precipitates.

Inks of all colors may be made by using a strong decoction of the ingredients used for dying, mixed with a little alum and gum-arabic. For example, a strong decoction of brasil wood with as much alum as it can dissolve, and a little gum-arabic to give it body and some consistence, forms a beautiful red ink. (l)

(l) As the duration of records and other valuable writings depends much on the goodness of the ink employed, Dr. Lewis has thought this subject worthy of his attention. The chief imperfection of common inks is, that they decay in time, and at last the writing becomes invisible. From experiments made by that author, he infers that the decay of inks is chiefly owing to a deficiency of galls; that the galls are the most perishable ingredient, the quantity of these, which gives the greatest blackness at first, (which is about equal parts with the vitriol) being insufficient to maintain the color; that for a durable ink, the quantity of galls cannot be much less than three times that of the vitriol; that it cannot be much greater without lessening the blackness of the ink; that by diminishing the quantity of water, the ink was rendered blacker and more durable; that distilled water, rain water, and hard spring water, had the same effects; that white wine produced a deeper black color than water; that the color produced by vinegar was deeper than that by wine; that proof

spirit extracted only a reddish-brown tinge; that the last mentioned tincture sunk into, and spread upon, the paper; and hence the impropriety of adding spirit of wine to ink, as is frequently directed, to prevent mouldiness or freezing; that other astringents, as oak bark, bistort, sloe-bark, &c. were not so effectual as galls, nor gave so good a black, the color produced by most of these, excepting oak-bark, being greenish; that the juice of sloes did not produce a black color with martial vitriol; but that, nevertheless, the writing made with it became black, and was found to be more durable than common ink; that inks made with saturated solutions of iron in nitrous, marine, acetous, acids, in tartar, or in lemon juice, were much inferior to the ink made with martial vitriol; that the color of ink was depraved by adding quicklime, which was done with an intention of destroying any superabundant acid which might be supposed to be the cause of the loss of the color of ink; that the best method of preventing the effects of this superabundant acid is probably by adding pieces of iron to engage it; and

**CCCLXXXIX. INKS (SYMPATHETIC).** Chemistry furnishes many methods of making the inks called sympathetic. These inks are colorless liquors, with which an invisible writing is made, but which becomes very sensible when we please, by certain treatment appropriated to the particular kind of sympathetic ink employed.

As ordinary ink is made black by a mixture of two liquors which are not, or but very little colored, it may become a sympathetic ink by several methods.

If green vitriol be dissolved in water, and a little acid be added, to prevent the yellowish martial precipitate, which is always formed when there is not superabundant acid, with this solution invisible characters may be written, which may be rendered very black, by being moistened with a strong infusion of galls.

If the blackness of ordinary ink be destroyed by a sufficient quantity of nitrous acid, the writing made by it will remain invisible, till it be moistened by liquid fixed alkali.

Characters traced with the acid solution of green vitriol above-mentioned will become of a fine blue color, if they be moistened with the phlogisticated alkaline liquor used in the preparation of Prussian blue; and characters traced with this last mentioned liquor, which are absolutely invisible, may be rendered of a fine blue color by being moistened with a solution of green vitriol. The theory of these inks may be seen under the articles *INK, and BLUE (PRUSSIAN)*.

Pure vitriolic acid, weakened by so much water that it shall not make too strong an impression upon paper, becomes a sympathetic ink, the characters written with which are invisible; but may be rendered sensible by heating the paper on which they are traced. This effect is occasioned by the heat concentrating the acid, and rendering it capable of burning and blackening the paper. But

and that this conjecture was confirmed by an instance the author had heard of the great durability of the color of an ink in which pieces of iron had been long immersed; and lastly, that a decoction of logwood used instead of water, sensibly improved both the beauty and permanency of the black, without disposing it to fade. The same author observes, that the addition of gum-arabic is not only useful, by keeping the coloring matter suspended in the fluid, but also by preventing the ink from spreading, by which means a greater quantity of it is collected on each stroke of the pen. Sugar, which is sometimes added to inks, was found to be much less durable than gums, and to have the inconvenience of preventing the drying of the ink. The color of ink is found to be greatly improved, by keeping the ink in vessels made of copper, or of lead, and probably of any other metal, excepting iron, which the vitriolic acid can dissolve. The foregoing experiments point out for the best proportions of the ingredients for ink; one part of green

vitriol, one part of powdered logwood, and three parts of powdered galls. The best menstruum appears to be vinegar or white wine, tho', for common use, water is sufficient. If the ink be required to be of a full color, a quart, or, at most, three pints, of liquor may be allowed to three ounces of galls, and to one ounce of each of the other two ingredients. Half an ounce of gum may be added to each pint of the liquor. The ingredients may be all put together at once in a convenient vessel, and well shaken four or five times each day. In ten or twelve days the ink will be fit for use, though it will improve by remaining longer on the ingredients; or it may be made more expeditiously, by adding the gum and vitriol to a decoction of galls and logwood in the menstruum. To the ink, after it has been separated from the feculencies, some coarse powder of galls, from which the fine dust has been sifted, together with one or two pieces of iron, may be added, by which its durability will be secured.

this

this ink is not convenient for use; because the vitriolic acid, although weakened by water, always injures the paper, and at length destroys it.

Amongst the most famous sympathetic inks is that made with the solution of bismuth in nitrous acid. The invisible characters written with this ink may be rendered sensibly black without being moistened or heated: but by being exposed to the contact of phlogiston reduced into vapors; because this phlogiston revives the earth of bismuth, which is partly calcined by the nitrous acid, and even applies itself, superabundantly, to that metallic earth, which it blackens so much more, as it is in greater quantity.

The phlogistic vapors exhaling from liver of sulphur are the fittest for producing this effect upon the solution of bismuth. The authors who first described this sympathetic ink, required that a solution of the *floria* of regulus of antimony, or of a mixture of quicklime and orpiment, should be employed: but as the former of these substances is an antimoniated liver of sulphur, and as the latter is an earthy liver of sulphur, mixed with arsenic, we may perceive that they produce their effects only as being livers of sulphur. The ordinary liver of sulphur is found to succeed equally well.

When therefore characters written with the sympathetic ink of bismuth are required to appear, exposure to the vapors of liver of sulphur is sufficient for that purpose; and these vapors are said to be capable of producing their effect across a quire of paper, or even a stone-wall. This does not appear impossible, but it must require a long time. We are certain, that the white precipitate of bismuth, nitrous crystals of bismuth, or of lead, although well covered with paper, become blackened on their surfaces by remaining in laboratories where phlogistic vapors float, particularly the vapors of liver of sulphur.

We may easily perceive that the writing made by this ink of bismuth may be more readily made to appear by being moistened with a solution of liver of sulphur. (*m*)

The most modern sympathetic ink, and, at the same time, one of the most curious, is that made with a solution of the regulus or calx of cobalt in aqua regia. The process of this ink has been published in the Memoirs of the Academy of Sciences by Mr. Hellot.

This process was very troublesome; because he directed that cobalt itself should be employed, which must be first roasted; then dissolved in nitrous acid; and, lastly, to the solution some sea-salt must be added; and also because good cobalt is very scarce. But this ink may be easily made. For this purpose, let the

(*n*) Instead of the solution of bismuth in nitrous acid, a solution of sugar of lead in water may be employed for the same purpose; and the writing made with this liquor is rendered black by vapors of liver of sulphur, or still more effectually by the solution of liver of sulphur in water. But as these chemical liquors may require more management than can be conveniently applied, or perhaps comprehended by some lovers, and other persons engaged in mysterious correspondencies; Ovid, that admirable instructor, has recommended a more familiar and domestic method of communi-

cating tender sentiments without danger of discovery from fathers or husbands. This method consists in writing with milk, which, by being held near a fire, is rendered visible. The juice of lemons has also been used with great success, for the same purposes, and in the same manner. The color given to these two last mentioned liquors proceeds from a beginning decomposition of their oily and mucilaginous particles by means of heat. Not only these liquors, but all the sympathetic inks, mentioned by authors, may be rendered more or less visible, by application of heat.

zaffre be taken which is commonly sold by druggists, from which, by digestion in aqua regia, may be extracted all that this acid is capable of dissolving: this soluble part of zaffre is the calx of cobalt, which is used for giving a blue color to glass. This solution is then to be diluted with a little common water, to prevent it from making too strong an impression upon paper. Characters written with this diluted solution are invisible when cold, and become of a fine greenish-blue when heated; and have this singular property, that after they have been rendered visible by heat, they again disappear when exposed to cold, and may thus be made to appear and disappear alternately, by alternate applications of heat and cold: but care must be taken to heat the paper no more than is just sufficient to make the writing appear; for when it is heated too much, the writing will not again disappear by exposure to cold.

This ink may be applied to the drawing of landscapes, in which the earth and trees destitute of verdure, being drawn with common ink, give a prospect of winter; and which may be made to assume the appearance of spring, by exposure to a gentle heat, which covers the trees with leaves, and the earth with grass, by rendering visible those parts of the landscapes which are drawn with this sympathetic ink. This idea has been executed upon fire-screens by an industrious artist (*n*).

By reflecting a little upon the properties of chemical agents, and on the phenomena of many operations, we may perceive that many new sympathetic inks with peculiar properties may be discovered.

CCCXC. INSTRUMENTS (CHEMICAL). The instruments employed in chemical operations are very numerous, and are described under their several articles. They are also enumerated in a general manner under the article LABORATORY.

CCCXCI. INTERMEDIUM, or INTERMEDIATE SUBSTANCE. Those substances are called *intermediate* by means of which other substances incapable of uniting together alone, may be united. For example, saline, acid, or alkaline substances, by means of which oils are reduced to a saponaceous state, and are thereby rendered miscible with water, are the intermediate substances of this union of oil with water; because, without these saline substances, oil and water cannot be united, or even well mixed.

Those matters are also called intermediate, which are employed to disunite others, which cannot be otherwise disunited. In this sense vitriolic acid is an intermediate substance, by which nitrous or marine acids may be separated from any alkali salt, with which they happen to be united.

CCCXCII. IPECACCOANHA. (*o*)

CCCXCIII. IRON. Iron, called also *Mars*, is a metal of a white, livid, greyish color. It is the hardest of all metals, the most elastic, and, ex-

(*n*) We may observe, that a solution of regulus of cobalt, or of zaffre, in spirit of nitre, acquires a reddish color by application of heat. Hence, some variety of color might be given to the landscapes proposed in the text. Thus while the green solution of this semi-metal in aqua regia represented the leaves, the red solution might represent the fruits and flowers.

(*o*) IPECACCOANHA. From sixteen ounces of good ipecacoanha, three ounces of resinous matter were extracted by means of spirit of wine; and from the same quantity, by means of water, five ounces of gummy matter were extracted. *Neuman*.



cepting platina, the most difficult to be fused. This metal has, next to gold, the greatest tenacity of parts; an iron wire, the diameter of which is a tenth part of an inch, being capable of sustaining 450 pounds, without being broken.

Next to tin, iron is the lightest of the metals. It loses when immersed in water betwixt a seventh and an eighth part of its weight. A cubic foot of forged iron weighs 580 pounds.

Very pure iron is sufficiently ductile to be drawn into wire as fine as horse-hair. But these properties of iron are subject to vary much in their degrees, according to the different kinds of iron. This difference proceeds from a quantity, sometimes greater and at other times less, of an earth contained in iron, which is unmetallic, or at least which is not metallised, from the great difficulty of fusing perfectly its ore. See ORES of IRON and SMELTING of ORES.

Iron is the only known substance which is attracted by magnets, and capable of becoming itself a magnet, so as to attract other iron. By this property it may be discovered in mixtures where by other methods it could scarcely be perceived, and may be even separated, when it is only interposed betwixt other bodies, and not adherent to them. It preserves this property, although it be alloyed with some other metals. Henkel says, in his *Pyritologia*, that iron alloyed with two parts of copper is still magnetical. (p)

Iron is a very destructible metal. Its surface is quickly converted by the combined action of air and water into a rust or yellow calx, deprived of all its phlogiston. This calx is only an earth deprived of metallic properties, and which cannot recover these properties, without being again combined with its inflammable principle. The destruction of iron exposed to a moist air by rust, is universally known. The rust of iron, and the other calxes of this metal, are called *saffron of Mars*, *crocus martis*. See SAFFRON of MARS.

Water alone, without the help of air, seems to be capable of acting upon iron in some measure, without depriving it indeed of its inflammable principle: but it divides and considerably attenuates it; which seems to shew that this metal contains some saline parts. See ETHIOPS MARTIAL.

Iron is not fusible by the heat of ordinary furnaces; but it is easily burnt and calcined, by which it is changed into an earthy matter more or less reddish or blackish, called *astringent saffron of Mars*. See that word. This saffron of Mars is nothing but the proper earth of iron deprived of the greatest part of its phlogiston by calcination.

Iron heated as much as is possible, that is, till it becomes of a shining white color, and just beginning to fuse, has the appearance of a combustible body, penetrated by a vivid and bright flame: and indeed the inflammable principle of this metal heated to that point, really burns in a sensible manner. A number of vivid and shining sparks shoot out from it, and burn with a kind of decrepitation. I have exposed iron to the focus of a large burning glass, where it quickly fused and boiled, and emitted an ardent fume, the

(p) A greatly smaller proportion of iron in an alloy of copper with that metal, retains its magnetical quality. Gellert affirms, that the magnetical quality of iron is destroyed by alloying it with regulus of antimony. He observes, that the surface of his alloy was

covered with spots like rust; which circumstance induces a suspicion that his iron might have been injured by sulphur, some of which is frequently retained by regulus of antimony.

lower part of which was a true flame. At length it was changed into a blackish vitriol scoria. The sparks struck from iron by flints are nothing but bits of iron heated by violent collision, and when collected upon paper, and viewed by means of a microscope, appear to be like scoria of iron, or slag. (7).

All the acids dissolve iron, and in their solutions exhibit particular phenomena.

If filings of iron be put into a matrafs, and a sufficient quantity of vitriolic acid added to dissolve it, the solution will be made with heat and effervescence. The vitriolic acid, when it dissolves the iron in this manner, takes from it much of its inflammable principle: for the vapors which exhale from this solution have not only a strong smell of volatile sulphureous acid, but they are so impregnated with phlogiston, that they are very inflammable. An experiment may be made to render this truth sensible by sight. Let the mouth of the matrafs be stopp'd by a finger during thirty or forty seconds, and a lighted candle be brought very near the mouth when it is to be unstopp'd; a flame will then immediately appear within the matrafs, and at the same time a strong explosion will happen. This explosion would break the matrafs, if the quantity of filings of iron was considerable, for instance eight or nine ounces, and if the neck of the matrafs was straight. This inflammation and this explosion may be frequently repeated, when the solution is made with some activity; and if the matrafs be left unstopp'd after the explosion, and the vapor be kindled, it continues to burn at the mouth of this vessel with a blue tranquil flame, while the solution continues. See AIR (FIXABLE INFLAMMABLE), and DAMPS.

From the solution of iron by vitriolic acid, a vitriolic salt with metallic basis is formed, which by evaporation and cooling is coagulated into green rhomboidal crystals. This salt is called *martial vitriol*, *green vitriol*, or *green copperas*. See its properties at the article VITRIOL (MARTIAL).

Nitrous acid dissolves iron most actively and violently. This acid cannot feebly be saturated with iron; because when it has dissolved a large quantity of iron, and seems to be so saturated, that some of the metal is deposited under

(7) Iron is a combustible substance, as appears from the great waste or loss of quantity observable in iron exposed to a red, but especially to a white heat. This combustion is maintained and excited, like that of all other combustible substances, by contact of air. Dr. Hook says, that having heated a bar of iron to that degree called white heat, he placed it upon an anvil, and blowed air upon it by means of bellows, by which it burnt brighter and hotter. The sparks produced by the collision of steel with flint, appear to be globular particles of iron which have been fused, and imperfectly scorified or vitrified. They are kindled by the heat produced by the collision; but their vivid light, and their fusion or vitrification, are the effects of a combustion continued in these particles

during their passage through the air; and these effects are so great in so short a time, because the quantity of surface of these minute particles of iron, and consequently the quantity of air applied to excite the combustion, is so great in proportion to the quantity of matter. This opinion, that the ignition, light, and fusion of the sparks are occasioned by the heat, excited by the combustion of their own inflammable matter, and not merely by the heat communicated by the collision, is confirmed by an experiment made and related by Mr. Hawksbee; from which we find that these sparks struck by collision are not visible, that is, they are not ignited, and do not deflagrate, in an exhausted receiver; the air being necessary to maintain and excite their deflagration and combustion.

form

form of martial saffron; if more iron be then added, it will be dissolved, while some of that which was before dissolved will be precipitated.

The cause of this phenomenon is, that the nitrous acid takes from the iron much of its phlogiston during the solution, and also that iron has so much less adhesion to nitrous acid, as it is more deprived of phlogiston. This being established, we may perceive, that when iron containing its due quantity of phlogiston is added to nitrous acid saturated with a half dephlogisticated iron, this acid, greedy of the inflammable principle, quits the latter metal, and dissolves the former.

The vapors of nitrous acid which dissolves iron are always very red, of a nauseous smell, more disagreeable, and apparently more volatile, than those of the uncombined acid. This observation may be applied to all solutions with nitrous acid of those metallic substances, which are capable of losing their inflammable principle. These qualities of nitrous acid proceed from the superabundant quantity of phlogiston, which it imbibes in every solution. Experiments might be made to try whether the vapors which exhale from this solution, and from solutions of several other metallic substances abounding in phlogiston, are inflammable, like those which exhale from a solution of iron in vitriolic acid. But these experiments ought to be made cautiously, lest explosions should happen.

Marine acid also dissolves iron with ease, and even with activity; but it does not take from the metal its inflammable principle so efficaciously as nitrous acid does, and even as vitriolic acid, although it does produce some change upon it in this respect. A great chemist affirms, that marine acid treated with iron acquires the properties of nitrous acid. (r)

Aqua regia dissolves iron with much impetuosity, and presents phenomena partaking of those of the solutions of this metal in the nitrous, and in the marine acids separately.

Iron forms with the nitrous and marine acids, separately or conjointly, salts with metallic bases, of a deliquescent nature.

When solutions of iron with any of the mineral acids are made with much superabundant acid, their color is more or less green, and they remain clear without making any deposition: but when the acid is saturated with metal, the color of the solution is more or less yellow or reddish, and a certain quantity of yellow ferruginous earth called *ockre* or *giffon of Mars* is deposited. These differences proceed from this cause, that iron requires so much more acid to keep it dissolved, as it is more deprived of its phlogiston.

Lastly, when solutions of iron, not too acid, and particularly when diluted with water, are heated, they become turbid, and immediately deposit a quantity of ochre, which they would not have deposited but in a long time, if they had not been heated.

Ochres, or saffrons of Mars, which are deposited from solutions of iron, are not so soluble as iron: they require a much greater quantity of acid, or cannot be again dissolved, particularly by nitrous acid, but by peculiar management.

Vegetable acids also dissolve iron. The acid of tartar forms with this metal a sort of vegetable metallic salt, or of soluble tartar, which is deliquescent.

(g) This great chemist is Stahl. The experiment has not been confirmed by other chemists.

cent; and is called **TINCTURE (TARTARISED) of MARS**; which *see*. Martial or vulnerary balls are made by mixing acid of tartar with filings of iron; which being dissolved in water furnish a true soluble martial tartar, or tartarised tincture of Mars. *See BALLS (MARTIAL)*.

Iron, like other metals, dissolved in any acid, may be precipitated by absorbent earths and alkaline salts. But this metal, like all others, presents, when precipitated by fixed alkalis, different phenomena, according to the particular state of the alkali.

If the alkali employed to precipitate iron is as much dephlogisticated as it can be, the ferruginous precipitate is of the color of rust. If this alkali contains any superabundant phlogiston, a part of this phlogiston will be transferred to the iron during its precipitation, and will give it an olive color, more or less deep. This precipitate may be easily and instantaneously redissolved by pouring upon it a quantity of acid sufficient to saturate the alkali, and to dissolve the precipitate. This precipitate, when dried with proper precaution, (*see* **ETHIOPS MINERAL**) forms an excellent saffron of Mars for the use of medicine. Lastly, if an alkali much impregnated, or still better, if saturated with phlogiston, be added, the precipitate will be of a blue color, and will form what is called *Prussian blue*. *See* **BLUE (PRUSSIAN)**.

Alkalis act upon iron as upon all other metals, and are even capable of dissolving it perfectly, when they can seize it sufficiently divided, as Stahl has discovered. For this purpose a solution of iron by nitrous acid is to be poured into good liquid alkali. Immediately afterwards a red precipitate appears, which, upon agitating the alkaline liquor, instantly dissolves, and communicates to the liquor its color. By this method a considerable quantity of iron may be dissolved by an alkali. When this solution contains much iron, it is called *martial alkaline tincture of Stahl*. This operation cannot succeed but in certain circumstances. These circumstances will be mentioned under the article **TINCTURE (MARTIAL ALKALINE) of STAHL**.

When this tincture is well impregnated with iron, a part of the metal is deposited in form of a very fine yellow brick colored saffron of Mars; and at the same time the tincture loses much of its color. All the iron may be quickly separated from it under the same form, by saturating this alkali with any acid. This ferruginous precipitate is called *Stahl's saffron of Mars*. It is rendered sufficiently soluble in acids by the phlogiston transferred to it from the alkali. *See* **SAFFRON of MARS**.

Iron precipitates metals dissolved in acids; and these precipitates have their metallic form and brilliancy, as all metallic precipitates, which have been separated from the acids of their solutions by other metals, have. But iron may be separated from acids by zinc, and by some other substances. *See* **PRECIPITATION and PRECIPITATE**. All vegetable astringent substances, as galls, pomegranate rind, &c. form inks, or black precipitates, with any solutions of iron. *See* **INK**.

Iron has a greater affinity than any other metal with sulphur: hence it may be employed to separate most metals from sulphur, by fusion; and sulphur thus united with iron, considerably augments its fusibility. *See* **ESSAYS of ORES, and REGULUS (MARTIAL) of ANTIMONY**.

If a bar of iron be heated till it becomes white, and a roll of sulphur be applied to one of its extremities thus heated, the sulphur, uniting with the iron, makes it fuse so as to run down in red-hot drops. This experiment ought to be made over an earthen pan filled with water, to receive the melted iron and sulphur, while they flow down copiously, that they may be extinguished as fast as they fall down, and that their dissipation may be prevented. In the earthen pan, after this operation, are found some parts of pure sulphur, which had melted without being combined with iron, and which are loosened (*see* SULPHUR); and other pieces composed of iron combined with sulphur, and which had been fused together. These latter pieces are brittle. They are iron artificially mineralised, or brought into a pyritous state by sulphur. *See* PYRITES.

Sulphur and iron act so strongly upon each other, that they can mutually dissolve each other even in the humid way. If five or six pounds of filings of iron be mixed with as much powdered sulphur, and the mixture be moistened with a sufficient quantity of water to form a paste, this mixture will in a certain time swell, become hot, melt, emit vapors, and even take fire. This is an experiment of Mr. Lemery the elder. The residuum of this operation furnishes martial vitriol, which has been produced by a transposition of acid from the sulphur to the iron. Here the same things happen as in the decomposition, effervescence, and inflammation of ferruginous pyrites. This union of the acid of vitriol with iron, and the formation of martial vitriol, may be much accelerated by heating and burning the sulphur, immediately after the mixture. *See* PYRITES, SMELTING of ORES, and VITRIOL.

As the phlogiston of iron is copious, and not much engaged, the filings of this metal when heated are capable of detonating with nitre, vividly and briskly. Hence they are said to be used by the Chinese in their fire-works.

After this detonation, iron is reduced to a reddish calx, called *Zwelfer's Saffron of Mars*. *See* SAFFRON of MARS.

In whatever manner iron be treated and calcined, the calxes, the ochres, the rusts, and the precipitates of this metal, are always colored; and the colors of ferruginous earth, in these different states, are from the yellow pale of rust to a red brown or blackish brown. Hence we are induced to believe that martial earth is never entirely deprived of phlogiston. This is also probably the cause that all these preparations of iron are easily susceptible of resuming phlogiston, and even in the humid way; for generally metallic calxes resume phlogiston so much more easily, as they have been less perfectly deprived of it.

These colors retained by calxes of iron render them fit to be used in painting, not only with oil, but also to tinge glass. Hence they are successfully employed for coloring glasses, or artificial precious stones, and for painting different shades of red upon pottery, enamel, and porcelain.

Iron may be alloyed with all metals excepting lead and mercury, with which it has not yet been rendered capable of uniting. *See* ALLAY and TINNING.

Lastly, one of the most interesting properties of iron is, that it is capable of being combined either by fusion or by cementation with a more abundant quantity of phlogiston; of being converted thereby into a more perfect iron called *steel*, which is capable of acquiring by sudden cooling or tempering a very great

great hardness, which renders it very useful for numberless necessary purposes. See STEEL.

The affinities of iron are, according to Mr. Geoffroy's table, in the following order: Regulus of antimony, silver, copper, and lead. These three last are placed so as to mark an equal degree of affinity with iron. But we must observe, that lead ought not to have been placed there, because it has no affinity with iron: but as iron united with silver may be instantly separated from the silver by addition of lead, which unites with the silver, and obliges the iron to float upon the surface of this new mixture; Mr. Geoffroy seems to have meant to have shown this effect in this column of his table of affinities, which however is not very accurate: for this experiment only shews, that silver quits iron to unite with lead. Mr. Gellert's table of solutions gives for the affinities of iron, gold, silver, and copper. Lead and mercury might be placed at the bottom of the column, where substances are mentioned which cannot be united with that which is placed at the head of the column. (s)

The uses of iron are so well known, and so numerous, that they need not be enumerated. We shall only observe, that no metal is so useful. It is, as it were, the soul of the arts, and is necessary for the existence of them all.

This metal furnishes also very efficacious remedies, the virtues of which are well established by practice. This is almost the only metal which is not virulent. It may be taken internally in substance, provided it be well divided in form of calx or saffron, or even when united with some acid, and in a saline form, without any danger. It never produces any bad effect, when applied in suitable quantity and circumstances.

The great medicinal virtue of iron is caused by its tonic and strengthening qualities. It produces a slight and gentle irritation of the fibres, the effect of which is, to constrict the sensible organic parts upon which it acts, and to increase their force and elasticity.

Iron particularly acts upon the fibres, and the vessels of the stomach and intestines: hence it produces excellent effects in all diseases which proceed from laxity and inactivity of the digestive organs; such are crudities, bad digestions accompanied with diarrhea, flatulencies, flatulent colics, &c. and in diseases which proceed from the former, as megrimis, many hysterical, hypochondriacal, and melancholic affections, intermittent fevers, tertians and quartans, &c.

Iron has also been always considered and administered by the best practitioners as a resolving and aperitive remedy. Stahl, however, and several other good physicians and modern chemists, acknowledge no other but the tonic and strengthening qualities of iron. If their opinion be well founded, the cases in which iron has produced a resolving and aperitive effect, are such where the obstructions, and the defect of secretions and excretions, have proceeded from weakness and re-

(s) Iron like other metals is said to consist of earth, phlogiston, and a metallic or mercurial principle. Teichmeyer relates an experiment by which the existence of the mercurial principle is pretended to be proved. He says, that by distilling iron filings, which had been exposed during a year to the air, then triturated, and afterwards exposed another

year to the air, he had obtained a hard matter which stuck to the neck of the vessel, and along with it some mercury.

Concerning the *smelting of iron ores*, and the other parts of the *Metallurgical History of Iron*, see SMELTING of ORES of IRON; and STEEL.

laxation of the fibres and of the vessels, rather than from a crassitude of humors; as in the chlorosis, in some kinds of jaundice, and in other diseases of the same sort.

The excrements of persons using martial remedies are blackish, or even black, which proceeds from a mixture of this metal dissolved with the aliments. This proves, that if iron penetrates farther than the primæ viæ, it must be in very small quantity, since the greatest part of it is ejected with the excrements.

As the principal effect of iron is to change the tone, the tension, and the spring of the solid parts of the body, this effect cannot be continued without a continuance of the martial remedy for some considerable time; otherwise only a transient relief would be given, and the disease would soon recur.

#### CCCXCIV. I S I N G L A S S. (t)

CCCXCV. J U I C E S of P L A N T S. The juices of several plants are expressed to obtain their essential salts, and for several medicinal purposes, with intention either to be used without further preparation, or to be made into syrups and extracts.

The general method of extracting these juices is, by pounding the plant in a marble mortar, and then by putting it into a press. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we shall soon observe.

The juices of all plants are not extracted with equal ease. Some plants even when fresh contain so little juice, that water must be added while they are pounded, otherwise scarcely any juice would be obtained by expression. Other plants which contain a considerable quantity of juice, furnish by expression but a small quantity of it, because they contain also much mucilage, which renders the juice so viscid that it cannot flow. Water must also be added to these plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method are not, properly speaking, one of their principles, but rather a collection of all the proximate principles of plants which are soluble in water; such as the saponaceous extractive matter, the mucilage, the odoriferous principle, all the saline and saccharine substances; all which are dissolved in the water of the vegetation of the plants. Besides all these matters, the juice contains some part of the resinous substance, and the green coloring matter, which in almost all vegetables is of a resinous nature (u). These two latter substances, not being soluble in water, are only interposed between the parts of the other principles which are dissolved in the juice, and consequently disturb its transparency. They nevertheless adhere together in a certain degree, and so strongly in most juices, that they cannot be separated by filtration alone.

(t) ISINGLASS is a glue prepared by boiling the skin, tail, fins, stomach, intestines, and bladder of a certain large fish frequent in the Russian seas and large rivers. It is totally soluble in water, but not at all in rectified spirit of wine. From eight ounces of isinglass were obtained, by distillation, four ounces and two drams of urinous spirit, half an ounce of concrete volatile salt, an ounce and a half of empyreumatic oil, half a scruple of fixed salt, and nine drams of

earth. Isinglass is employed as a glue for many purposes, and for fining wines. *Neuman.*

(u) The coloring substance of vegetables does not seem to be a resinous or gummy matter, but only to adhere accidentally to the resinous or gummy matters of plants; for when it has been separated from these so as to form with earth of allum the precipitates called *lakes*, it is not soluble either by water or by spirit of wine. *See DYEING.*

When therefore these juices are to be clarified, some previous preparations must be used by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are spontaneously clarified by rest and gentle heat. The juices of most antiscorbutic plants abounding in saline volatile principles, may be disposed to filtration merely by immersion in boiling water; and as they may be contained in closed bottles while they are thus heated in a water-bath, their saline volatile part, in which their medicinal qualities chiefly consist, may thus be preserved. Fermentation is also an effectual method of clarifying juices which are susceptible of it; for all liquors which have fermented, clarify spontaneously after fermentation. But this method is not used to clarify juices, because many of them are susceptible of only an imperfect fermentation, and because the qualities of most of them are injured by that process.

The method of clarification most generally used, and indispensably necessary for those juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and separates it from the juice in form of scum, together with the greatest part of the resinous and earthy matters which disturb its transparency. And as any of these resinous matters which may remain in the liquor, after this boiling with the whites of eggs, are no longer retained by the mucilage, they may easily be separated by filtration. *See FILTRATION.*

The juices, especially before they are clarified, contain almost all the same principles as the plant itself, because in the operation by which they are extracted no decomposition happens, but every thing remains, as to its nature, in the same state as in the plant. The principles contained in the juice are only separated from the grosser, oily, earthy, and resinous parts, which compose the solid matter that remains under the press. These juices, when well prepared, have therefore exactly the same medicinal qualities as the plants from which they are obtained. They must evidently differ from each other as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in those respects.

CCCXCVI. I V O R Y - B L A C K. (x)

CCCXCVII. J U P I T E R. By this name the old chemists distinguished tin. *See TIN.*

(x) *See the article BLACK.*



## K.

CCCXCVIII. **K** A L I. (y)  
 CCCXCIX. **K** A O L I N. (z)

CCCC. **K** A R A T. This name is applied to the proportional parts which are supposed to be in any mass of gold, the value or purity of which is to be ascertained. When therefore gold is considered with regard to its degree of purity, the whole mass of it, whatever be its real weight, is supposed to be divided into 24 parts, and these parts are called karats. Hence, when gold is entirely pure, and without alloy, it is called gold of 24 karats. If it contains  $\frac{1}{24}$  part of alloy, it is called gold of 23 karats, because in such a mass  $\frac{23}{24}$  are gold, and  $\frac{1}{24}$  is alloy. If the mass of gold be  $\frac{22}{24}$  or  $\frac{11}{12}$  of alloy, it is called gold of 22 karats, and so on. For greater precision, the karat is supposed to be subdivided into 32 parts, which have no other name than the thirty-second parts of a karat (a). See *ESSAY of the VALUE of GOLD and of SILVER.*

(y) **KALI** is a maritime plant, from the ashes of which a considerable quantity of mineral fixed alkali is obtained by lixiviation. See **ALKALI (FIXED MINERAL)**. Henkel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a considerable quantity of sea-salt.

(z) **KAOLIN** is the name of an earth which is used as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by Mr. Reaumur. He found that it was perfectly unfusible by fire. He believed that it was a talky earth; but the author of this Dictionary justly observes, that it is more probably an argillaceous earth, from its forming a tenacious paste with the other ingredient called *petunse*, which has no tenacity. Mr. Bomare says, that by analysing some Chinese kaolin,

he found it was a compound earth consisting of clay, to which it owed its tenacity; of calcareous earth, which gave it a mealy appearance; of sparkling particles of mica, and of small gravel or particles of quartz crystals. He says, that he has found a similar earth upon a stratum of granite, and conjectures that it may be a decomposed granite. See **PORCELAIN.**

(a) The karat, or carat, in England is divided into four parts only, called grains, and in Germany into twelve parts. Standard gold in England is gold of twenty-two carats, that is, which contains  $\frac{1}{4}$  part of alloy, which is generally an equal mixture of copper and silver; as the whole proportion of the copper would make the gold too high-colored, and the whole proportion of the silver would make it too pale.

The word karat, when applied to diamonds, signifies a real weight of four grains.

CCCCI. K E R M E S. (b)

CCCCII. K E R M E S M I N E R A L. Kermes mineral, so called from its color, which resembles that of vegetable kermes, is one of the most important antimonial preparations, both with regard to its chemical phenomena and to its medicinal uses.

The use of kermes mineral was not established in medicine before the beginning of this century. Some chemists, indeed, amongst others Glauber and Lemerici, had before that time mentioned in their works several preparations of antimony which approach more or less to kermes; but these preparations being little known, were confounded with many others which are entirely neglected, although much praised by their authors.

The fame of kermes was occasioned by Friar Simon, apothecary to the Chartreux Friars. This friar received this preparation from a surgeon called La Ligerie, who had procured it from a German apothecary who had been a scholar of the famous Glauber. Friar Simon, from the commendations given to this new remedy by La Ligerie, administered it to a Chartreux Friar, who was dangerously ill of a violent peripneumony, by which the Friar was suddenly, and as it had been miraculously, cured. From that time the Friar apothecary published the virtue of his remedy. Several other remarkable cures were performed by means of kermes. The public believed in its medicinal qualities, and called it *Powder of Chartreux*; because it was prepared only in the apothecary's shop belonging to these monks. The reputation of kermes extended itself more and more; till at length the Duke of Orleans, then Regent of France, procured the publication of the process by La Ligerie.

This is the history of kermes, as it is related by Mr. Baron, in his edition of Lemerici's Chemistry. Although the process for making this preparation be very accurately described in this and other books, we shall treat of it in detail, because it is a matter of much importance.

The process for kermes, published by La Ligerie, consists in boiling, during two hours, pulverised crude antimony in the fourth part of its weight of the liquor of nitre fixed by coals, and twice its weight of pure water: at the end of this time the liquor is to be decanted and filtrated, while boiling, through brown paper. It continues clear while it is boiling hot; but when it cools, it becomes turbid, acquires a red brick color, and again becomes clear by the deposition of a red sediment, which is the kermes. The boiling may be thrice repeated, and each time the same quantity of water is to be added to the antimony, and a fourth part less of the liquor of fixed nitre. The several sediments from these three boilings are to be added together, washed with clean water, till the water acquires no taste; and the kermes is then to be dried. La Ligerie directs, that aqua vitæ shall be once or twice poured upon it and burnt, and the kermes dried again.

(b) KERMES are excrescencies formed by insects on the branches and leaves of the scarlet oak. They communicate a red color to water or to spirit of wine. Woollen cloth, previously dipped in a solution of alum and

of tartar in water, receives from a decoction of kermes a more durable, but less vivid, scarlet dye than that usually procured from cochineal, together with a solution of tin.

We now proceed to explain the nature of kermes, and the phenomena of its preparation.

Crude antimony is composed of regulus of antimony and common sulphur, united naturally with each other, as in almost all metallic minerals. The fixed alkali with which the crude antimony is boiled, although it is diluted with much water, acts upon the sulphur of the antimony, and forms with it liver of sulphur; and as this compound is a solvent of all metallic matters, it dissolves a certain quantity of the regulus of antimony. In this operation then a combination is formed of fixed alkali, of sulphur, and of regulus of antimony. Of these three substances the fixed alkali only is soluble in water, and is the intermediate substance by which the sulphur and regulus are suspended in the water. But we are to observe, that the alkali becomes impregnated by this operation, and by boiling, with a larger quantity of regulus, and especially of sulphur, than can be suspended in cold water; hence the decoction of kermes, which is clear, limpid, and colorless while boiling hot, becomes turbid, and deposits a sediment while it cools. This compound, therefore, like certain salts, may be kept dissolved in larger quantity by hot than by cold water, and much of it is therefore deposited by cooling.

Further, while the kermes is precipitating, the whole antimonial liver of sulphur, which is dissolved by the boiling liquor, may be divided into two parts; one of which, that is the kermes, being overcharged with the regulus, and particularly with the sulphur, contains but a little alkali, which it draws along with it during its deposition. The other part, as it contains much more alkali, remains dissolved even in the cold liquor, by means of this larger quantity of alkali. All these propositions are to be explained and demonstrated by the following observations.

First, when the decoction of kermes is cold, and has formed all its sediment, if, without adding any thing to it, it be heated all it boil, it again entirely re-dissolves the kermes; the sediment disappears; the liquor becomes clear, and by cold is again rendered turbid, and deposits sediment as before. Thus the kermes may be made to precipitate and to re-dissolve as often as we please.

Secondly, by digesting kermes in aqua regia, which dissolves its alkali and regulus, the sulphur is separated pure. The acids of aqua regia form a nitre and a febrifugal salt of Sylvius with the alkali of the kermes; and if a certain quantity of kermes be melted with black flux, after having destroyed its sulphur by roasting, a true regulus of antimony may be obtained from it.

These experiments, which were made by Mr. Geoffroy, and the detail of which is found in Memoirs given to the Academy in the years 1734 and 1735, upon the Analysis of Kermes, shew evidently the presence of sulphur, of fixed alkali, and of regulus of antimony, in this compound. From Mr. Geoffroy's experiments we find, that 72 grains of kermes contain about 16 or 17 grains of regulus, 13 or 14 grains of alkaline salt, and 40 or 41 grains of common sulphur.

Thirdly, by repeating the boiling of the liquor upon the antimony, more and more kermes will be formed each time by cooling, as at first; and this experiment may be repeated a great many times. Mr. Geoffroy says, that he repeated it 78 times, without any other addition than that of pure water, to supply that which was lost by evaporation; and that each time a considerable quantity of kermes

kermes was formed by cooling. This experiment proves, that the alkali transforms the antimony into kermes by overcharging itself with regulus and sulphur, and at each precipitation the kermes does not retain and take with it but a very small quantity of alkali.

Fourthly, if any acid be poured upon the liquor in which the kermes has been formed, and from which it has been entirely separated by cooling, Mr. Beaumé has observed, that this liquor is again rendered turbid, and that a second sediment is formed of a yellow reddish color, which is nothing else than golden sulphur of antimony; that is, regulus of antimony and sulphur mixed together, but in very different proportions, and with different strengths of union, from those in which they are found in the crude antimony. See SULPHUR (GOLDEN) of ANTIMONY.

After this precipitation, in the liquor a neutral salt is left, which is formed by the contained alkali and the precipitating acid. From this experiment we find, that in the liquor from which the kermes has been deposited, a considerable quantity of antimoniated liver of sulphur remains, which differs from kermes by containing a much larger proportion of alkali; so that it can keep dissolved the regulus and sulphur with which it is united, even when the liquor is cold.

From what has been said concerning the manner in which kermes is formed, and the phenomena presented by this operation, we ought to understand well what it consists of. It is evidently nothing else than an antimoniated liver of sulphur, in which the sulphur predominates, and which contains too little alkali to be soluble in water. On this last article we may observe, that kermes after its spontaneous separation, and before it has been washed, contains much more alkali than after it has been washed; whence, if the kermes has been washed with very hot water, a part of it will be re-dissolved; but as the water always takes away the part which is most alkaline, the kermes which remains at last contains so little alkali, that it is no longer soluble even in boiling water; and then it has all the qualities peculiar to it.

In the processes for several antimonial preparations, a kermes, or compounds like it, are formed. This always happens when crude antimony is treated by fusion with a quantity of alkaline salt, so that an antimoniated liver of sulphur results from it, overcharged with regulus and sulphur; that is, containing more of these two substances than it can keep dissolved in cold water. If any of these combinations be boiled in water, a matter analogous to kermes is always deposited by cooling. This happens, for instance, to the scoria of the regulus of antimony, and in an operation described by Mr. Geoffroy to abridge the process for making kermes by fusion.

To make kermes by fusion, Mr. Geoffroy fuses two parts of antimony with one part of alkaline salt; he powders this matter while yet hot, and keeps it during two hours in boiling water; he then filtrates it, and receives the liquor into more boiling water, from which, when it cools, about six gros of kermes is deposited, when an ounce of antimony has been used. This method of making kermes is much more expeditious, but less perfect; for, as the author confesses, the kermes produced is not so fine and soft as that made in the ordinary method.

Mr. Lemerî the elder mentions also, in his Treatise concerning Antimony, an operation from which his son pretends that kermes may be obtained. This operation consists in digesting and afterwards boiling powdered crude antimony in a very pure liquor of fixed nitre. This liquor, if it be in sufficient quantity, is capable of dissolving quickly and entirely powdered crude antimony, and we cannot doubt but that by cooling a considerable quantity of a substance very analogous to kermes will be produced. Nevertheless, none of these short methods of making kermes is directed by dispensatories, or by the best books for describing the preparations of chemical remedies; and we must allow, that this is done prudently; for, besides that all these kinds of kermes may be suspected to be less fine, or more charged with reguline parts than that which is prepared by the ordinary process; when the constant observation of medical practitioners has ascertained the effects of a compound remedy; such a remedy ought to be considered as it were consecrated by a respectable kind of empiricism, against which the finest theory and most specious reasonings ought not to avail. The least reformation or innovation ought then to be considered as a blamable rashness, particularly when a remedy of such importance is concerned.

Kermes is used in medicine only, and from it singularly excellent effects may be produced, when administered by able physicians. In kermes are united the citing and evacuant virtues of the emetic preparations of antimony, with the tonic, dividing, aperitive, and resolving properties of the liver of sulphur; that is to say, that it is capable of answering two principal indications in the treatment of many acute and chronic diseases. Properly managed, it may become an emetic, purgative, a diuretic, a sudorific, or an expectorant, as is required, and it is always attenuating and resolving. When seven or eight grains are taken at once, it chiefly acts upon the primæ viæ, generally as an emetic and as a purgative. A dose of three or four grains is seldom emetic, and more frequently purgative.

When taken in these quantities as an evacuant, a little of it passes also into the viæ secundæ & tertiæ. When it is administered in smaller doses, it passes almost entirely into the lacteal, blood, and lymphatic vessels. In these it occasions such spasms and oscillations as it does in the primæ viæ; so that it increases all secretions and excretions, but particularly those of urine, sweat, and expectoration. According to the dose, to the nature of the disease, and to the disposition of the patient. It produces singularly good effects in those diseases of the breast which proceed from tenuity and obstruction.

Kermes may be administered in linctus's, in oily or in cordial potions, in any vehicle; or incorporated in a bolus, with other suitable remedies. One precaution, hitherto little observed, is very necessary, that is, not to join it with acid matters, if it is intended to act as kermes. Anti-acid and absorbent substances ought to be joined with it, if the patient has an acid in the primæ viæ, or an acescent disposition; for as these acids saturate the alkali by which the kermes is rendered an antimoniated liver of sulphur, and by which alone it differs from golden sulphur of antimony, they accordingly render the kermes entirely similar to the golden sulphur of antimony, the properties of which are very different from those of kermes. See SULPHUR (GOLDEN) of ANTIMONY. In some cases, we certainly ought to prefer the unwashed kermes to that which

has been washed, and therefore apothecaries ought to keep both the kinds, as Mr. Baron proposes in his edition of Lemeris's Chemistry.

CCCII. KINGDOMS. Most naturalists and chemists divide all natural bodies into three great classes, which they call kingdoms. These are the *mineral*, the *vegetable*, and the *animal kingdoms*.

This great and first division is founded on this consideration, that any plant or vegetable which is produced, which grows, which is organised, which contains a seed, and which produces its like, seems to be a being very distinct and different from a stone or a metal, in which we at most observe only a regular arrangement of parts, but not a true organisation, and which contains no seed by which it is capable of reproduction; and another foundation of this division is, that an animal differs no less from a simple plant, by sensation, by the use of its senses, and by the power of voluntary motion which it possesses, while these qualities do not belong to any thing which is merely vegetable.

But notwithstanding these marks so distinctive, some philosophers pretend, that this division into classes of natural bodies is only ideal. They affirm, that by observing nature attentively, we may perceive that all her productions are connected together by an uninterrupted chain; and that by surveying the several beings, we must be convinced that any one being differs very little from some other two, betwixt which it seems to be placed; so that we may descend from the most perfect animal to the rudest mineral by insensible degrees, and without finding any interval from which a division might be made.

This idea is certainly great, sublime, and not improbable; for if we compare a *polyus* with the *sensitive plant*, or a *lichen* with a beautiful ore of ramified native silver, we shall be inclined to consider this opinion as conformable to the plan of nature.

The opinions of naturalists are therefore divided upon this subject, and each opinion seems to be founded on observations, analogies, and reasonings more or less conclusive. But as the discussion of this matter is foreign to our subject, we shall not enter into a more particular detail, but we shall consider natural bodies only in a chemical view; that is to say, relatively to the several principles which we obtain in the analysis of those bodies. We proceed therefore to shew what experiments have taught us on this subject. In the decomposition of all beings truly living, organised, and containing within themselves a seed by which they may be reproduced, such as vegetables and animals, we always obtain an inflammable, fat, or oily substance; and on the contrary, we do not find the smallest trace of this principle in any substance purely mineral, not even in sulphur, which is the most inflammable of all these substances. On the other side, if we carefully examine and compare, with each other the analogous principles obtained from the three kingdoms, such as the saline substances obtained in the analysis of animals, vegetables, and minerals; we shall easily perceive that all the saline matter which comes from the vegetable or animal kingdoms is altered by oil, while all the saline matter which comes from the mineral kingdom is entirely free from oil.

We ought to observe here, that because any matter is found in one or more individuals of any kingdom, we must not therefore conclude, that it belongs to the kingdom of such individuals; for we may be convinced from a slight observation of nature, that by a thousand combinations, and particular circumstances, substances

substances of quite different classes or kingdoms are daily found mixed and confounded together. Thus, for example, within the earth, and even at great depths, that is, in the region appropriated to minerals, sometimes substances are found evidently oily, such as all *bitumens*: but we at the same time can prove, and all the observations of natural history prove, that these oily substances are only accidentally within the earth, and that they proceed from the vegetable or animal bodies which have been buried in the earth by some of those great revolutions which have happened from time to time upon the surface of our globe. Also in decomposing several vegetables and animals, salts are obtained; such as common salt, Glauber's salt, and others, which contain nothing oily, and which are consequently matters evidently mineral. But, on the other side, we are certain that these mineral salts are extraneous to the animals and vegetables in which they are found; that they are only introduced into these living bodies, because they happen to be mixed with the matters which have been applied to them as aliments, and that they ought not to be numbered amongst their principles. The proof of this is, that not only the quantity of these mineral salts is not uniform in animals and vegetables, but also, that not a particle of such salts is contained in some plants and animals equally strong and healthy, and of the same species as those in which these salts have generally been observed.

In the second place, we observe, that oils do only exist in the proximate principles of vegetables and animals; that is, in those of their principles which enter immediately into their composition, when these principles have not been altered by further decompositions, and consequently when they still preserve their animal or vegetable character; for, by a natural putrefaction continued during a long time, or by chemical operations, not only the materials of which animal and vegetable bodies are formed, may be deprived entirely of oil, but also this oil may itself be entirely destroyed or decomposed. These substances in that state contain nothing by which they can be distinguished from minerals. The earths, for example, of vegetables and animals, when they are deprived, by a sufficient calcination, of all inflammable matter, become entirely similar to the calcareous and argillaceous earths found within the globe, and which may be considered as mineral substances, although probably they have been formerly a part of animal and vegetable bodies. Further, if vegetable acids were deprived of all their oily parts, which is perhaps very possible, then they would entirely resemble the mineral acids, probably the vitriolic and marine, and would lose all the characteristic properties of vegetable acids.

Hence we conclude, that when we consider natural bodies in a chemical view, we ought to divide them into two great classes. The first class is of substances inanimate, unorganised, and the principles of which have a degree of simplicity which is essential to them: these are minerals. The other class contains all those bodies which not only have been distinctly organized, but which also contain an oily matter, which is no where found in substances which have not made part of animate bodies, and which, by combining with all the other principles of these animate bodies, distinguishes these principles from those of minerals by a less degree of simplicity. This second class contains vegetables and animals. We ought also to remark, that the oil contained in vegetable and animal substances renders them susceptible of fermentation, properly so called,

which cannot by any means take place in any mineral. *See* ACIDS, BITUMINS, FERMENTATION, OILS, PUTREFACTION, and EARTHS.

We shall now proceed to examine, if, by comparing the principles obtained in the decomposition of vegetables with those obtained in the decomposition of animals, we can find some essential character by which these two kingdoms may be chemically distinguished, in the same manner as we have seen that both of them may be distinguished from minerals. From experiments we indeed learn, that the principles of vegetables differ evidently enough from those of animals; that in general the saline principles of the former are acid, and are transformable in great measure into fixed alkali by incineration, while the principles of the latter are volatile alkalis, or easily changeable into these; that vegetables are much farther removed from putrefaction than animals; lastly, that oils truly animal have a character different from vegetable oils, and are in general more attenuated, or at least more disposed to be attenuated and volatilised. But we must, at the same time, confess, that these differences are not clear and decisive, like those betwixt these two kingdoms and the mineral kingdom; for we do not find any essential principle, either in animals or in vegetables, which is not also to be found in the other. In some plants, chiefly the cruciform, as much volatile alkali, as little fixed alkali, and as much disposition to putrify, are found, as in animal matters; and thence we conclude, that if these two great classes of natural bodies differ chemically from each other, this difference proceeds only from the quantities or proportions of their several principles and properties, and not from any thing distinct and peculiar, nor is it similar to the manner in which both vegetable and animal substances differ from minerals, namely, by containing an oil, and possessing a fermentable quality. Besides, the degrees of the chemical differences betwixt these three great classes of natural bodies are found to be the same, in whatever manner we consider them or compare them together.

#### CCCIV. KUPFER-NICKEL. (c)

(c) KUPFER-NICKEL is a reddish yellow mineral containing the semi-metal called nickel, together with iron and cobalt, mineralised by arsenic and by sulphur. It is

sometimes of a vitreous texture, sometimes fine-grained, and sometimes consisting of scaly particles. *See* NICKEL.



## L.

CCCCV. **L**ABORATORY (CHEMICAL). As chemistry is a science founded entirely on experiments, we cannot hope to understand it well, or to possess a certain degree of it, without making such experiments as shall verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, how many qualities are in the several chemical agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses?

Whoever therefore would become a chemist, must indispensably have a laboratory, furnished with the most necessary instruments for the practice of this science; and we therefore think proper to mention what these are. Our intention is not to speak in this article of laboratories designed for operations in the great, nor of those which are appropriated to some particular part of chemistry; as, for example, to essays, enamels, &c. but of the kind of laboratory which is proper for a philosophical chemist, to make occasionally, in small, any chemical operation whatever. Such a laboratory necessarily occasions certain expences, but not so much as is generally believed, when the operator knows how to manage his utensils, and to employ only the proper quantity of the several substances upon which he operates; and lastly, when he chuses the least expensive methods of attaining his purposes.

Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but it is also subject to a very great inconvenience from moisture.

Constant moisture, tho' not very considerable and sensible in many respects, is a very great inconvenience in a chemical laboratory. In such a place, moist saline matters become moist in time; the inscriptions fall off, or are effaced; the bellows rust; the metals rust; the furnaces moulder, and every thing almost spoils. A laboratory therefore is more advantageously placed above than below the ground, that it may be as dry as is possible. The air must have free access to it, ~~and it must even be so constructed, that, by means of two or more~~ opposite openings, a current of air may be admitted to carry off any noxious vapors or dust.

In the laboratory a chimney ought to be constructed, so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another. The tube of this chimney ought to be as high as is possible, and sufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no soot is collected in it; and therefore it need not be so wide as to allow a chimney-sweeper to pass up into it.

Under this chimney may be constructed some brick-furnaces, particularly a melting furnace, a furnace for distilling with an alembic, and one or two ovens like those in kitchens. The rest of the space ought to be filled up with stands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. These furnaces are the most convenient, from the facility of disposing them at pleasure; and they are the only furnaces which are necessary in a small laboratory. A double bellows of moderate size must also be placed as commodiously under the chimney, or as near as the place will allow. These bellows are sometimes mounted in a portable frame, which is sufficiently convenient when the bellows is not more than eighteen or twenty inches. These bellows ought to have a pipe directed towards the hearth where the forge is to be placed.

The necessary furnaces are, the simple furnace, for distilling with a copper alembic; a lamp furnace; two reverberatory furnaces, of different sizes, for distilling with retorts; an air or melting furnace; an assay furnace, and a forge-furnace. *See the enumeration and description of these furnaces under the words FORGE and FURNACE. See also PLATES.*

Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls; upon which are to be hung small shovels, iron pans; tongs; straight, crooked, and circular pincers; pokers; iron rods, and other utensils for disposing the fuel and managing the crucibles.

To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, one cannot have too many shelves.

The most convenient place for a stone or leaden fountain to contain water is a corner of the laboratory, and under it a cistern ought to be placed with a pipe by which the water poured into it may discharge itself. As the vessels are always cleaned under this fountain, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, small

small filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory, are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar, another to support a middle-sized marble, or rather hard-stone mortar, a third to support an anvil. Near the mortars are to be hung scarves of different sizes and fineness; and near the anvil are hung a hammer, files, raps, small pincers, scissars, sheers, and other small utensils, necessary to give metals a form proper for the several operations.

Two moveable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place. See FILTRATION and FILTER.

Charcoal is an important article in a laboratory; and it therefore must be placed within reach: but as the black dust which flies about it whenever it is stirred is apt to soil every thing in the laboratory, it had better be in some place near the laboratory, together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quicklime, sand, and many other things necessary for chemical operations.

Lastly, a middle-sized table, with solid feet, ought to be enumerated amongst the large moveables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard and dense grit-stone, together with a grinder made of the same kind of stone.

The other small moveables or utensils of a laboratory are, small hand-mortars of marble, iron, and glass, and their pestles; earthen, stone, metal, and glass vessels; an enumeration of which see under the article VESSELS, and a description under their respective names.

Some white writing-paper, and some paper not glued for filtrations; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels.

Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and of glass.

Thin pasteboards and horns, very convenient for collecting matters bruised with water upon the levigating stone or in mortars; corks of all sizes; bladders and linen strips for luting vessels. See LUTES.

A good portable pair of bellows; a good steel, for striking fire; a glue pot, with its little brush; lastly, a great many boxes of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves.

Besides these things, some substances are so necessary in most chemical operations, that they may be considered as instruments necessary for the practice of this science. These substances are:

All metals and semi-metals, which ought to be very pure.  
Vitriolic acid, some of which ought to be concentrated and rectified, and also some of that sort commonly sold by druggists.

Aqua fortis, such as is commonly sold, and is cheap; also spirit of nitre moderately strong, but very pure: the same acid very pure, concentrated, and smoking.

Common spirit of salt. Some of the same acid very pure, very strong, and smoking. All these acids ought to be kept in crystal glass bottles, and closed with glass stoppers.

Some distilled vinegar, which may be kept in an ordinary bottle; some radical vinegar, which ought to be kept in a bottle with a glass stopper; some cream of tartar, in an earthen or glass vessel, or in a box.

Common fixed vegetable alkali, very dry, such as pot-ash, which must be kept in a well closed bottle. The same alkali in a liquid state.

Very pure salt of tartar, some dry, and some liquid.

Mineral alkali, liquid; that is, a solution of soda. The same alkali dry and very pure; that is, well formed crystals of soda.

The two fixed alkalis liquid, and rendered caustic by quicklime. Alkalis, particularly those which are caustic, ought to be kept in bottles with glass stoppers. Some phlogisticated fixed alkali, or even saturated so as to be fit for making Prussian blue.

Some dry liver of sulphur kept in a well closed bottle. The same liquid. Some common sulphur.

Very pure alkali of sal ammoniac, disengaged by a fixed alkali, some solid, and some liquid, kept in a bottle with a glass stopper.

Fluor spirit of sal ammoniac disengaged by quicklime, as strong as is possible. Some of this spirit may be kept of less strength.

Lime water, and quicklime, in well closed bottles.

The purest and highest rectified spirit of wine.

Good vitriolic ether.

Rectified essential oil of turpentine; oil of olives & soap.

Galls; syrup of violets; tincture of turnsol, or turnsol in rags, fine blue paper; river or distilled rain-water.

Besides these substances, most of which are solvents, certain neutral salts ought to be had which are frequently used in chemical operations, or are difficultly prepared. These are:

Vitriolated tartar; alum, and calcined alum; green vitriol; blue vitriol; nitre; decrepitated common salt; some of the same salt very pure dissolved in distilled water; purified sal ammoniac; calcined borax; sedative salt.

A pure solution of silver in spirit of nitre; a solution of mercury in the same acid; butter of antimony. All these to be kept in bottles with glass stoppers. Corrosive sublimate.

Cerufs; litharge; minium; sand washed and ground; white marble, washed chalk; glass of lead; glass of borax. See the nature and properties of all these matters under their respective names.

A person, provided with the above-mentioned instruments and substances, may at once perform any chemical experiment. He may indeed occasionally want several neutral salts which have not been named; but all these salts with bases of earths, metals, fixed or volatile alkalis, may be easily and instantly prepared, as most of them do not require distillation or sublimation. They may nevertheless,

nevertheless, if they are not too numerous, be all previously prepared and kept ready for any occasions.

We ought not to finish this article without making some observations important to those who propose to give themselves up to the study of chemistry. They ought to be well persuaded that method, order, and cleanliness, are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place: inscriptions ought to be fastened upon all the substances. These cares, which seem to be trifling, are however very fatiguing and tedious; but they also are very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly; some seem nearly to decide the matter, and others suggest new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he shall easily know again the products of the first experiments, and therefore he does not take time to put them in order: he prosecutes with eagerness the experiments which he has last thought of; and, in the mean time, the vessels employed, the glasses and bottles filled, to accumulate, that he cannot any longer distinguish them; or, at least, he is uncertain concerning many of his former products. This evil is encreased if a new series of operations succeed, and occupy all the laboratory; or if he is obliged to quit it for some time: every thing then goes into confusion. Thence it frequently happens that he loses the fruits of much labor, and that he must throw away almost all the products of his experiments.

The only method of avoiding these inconveniences is to employ the cares and attentions above-mentioned. It is indeed disagreeable to stop continually in the middle of the most interesting researches, and to employ a very precious and considerable time in cleaning vessels, arranging them, fastening inscriptions on them, &c. These employments are capable of cooling or retarding the progress of genius, and are tedious and disgustful; but they are nevertheless necessary. Those persons whose fortune enables them to have an assistant operator, on whose exactness and intelligence they can depend, avoid many of these disagreeable circumstances; but they ought nevertheless to attend to the execution of these things. We cannot depend too much on ourselves in these matters, however minute, on account of their consequences. This becomes even indispensable when the experiments are to be kept secret, at least for a time; which is often necessary in chemistry.

When new researches and inquiries are made, the mixtures, results, and products of all the operations ought to be kept a long time, distinctly labelled and registered; for these things, when kept some time, frequently present phenomena that were not at all suspected. Many fine discoveries in chemistry have been made in this manner, and many have certainly been lost by throwing away too hastily or neglecting the products.

Lastly, we cannot too much recommend to chemical operators to be exceedingly upon their guard against imposing and deceitful experiments, which frequently present themselves in practice. A circumstance seemingly unimportant, or not easily perceptible, is frequently sufficient to give the appearance of a great discovery, by means of certain effects, which, nevertheless, are found to proceed from some other cause. Chemical experiments depend on so many accessory things, that all of them can seldom be attended to, particularly when

the subject is new: hence we frequently find that very different results proceed from the same experiment, made at different times. We therefore must not decide after the first success; but the experiment must be repeated several times, and even varied, till no doubt can remain.

Further, as chemistry offers many views for the improvement of many important arts; as it presents prospects of many useful and profitable discoveries; those who apply their labors in this way ought to be exceedingly circumspect not to be led into an useless expence of money and time. Those researches which have some analogy with the philosopher's stone, from the hopes of wealth which they suggest, are also attended with similar danger. In a certain set of experiments some one is generally of an imposing appearance, although in reality it be nothing more. Chemistry is full of these half-successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expence before the fruitlessness of the search be discovered. By these reflexions we do not intend to divert from all such researches those whose taste and talents render them fit for them; on the contrary, we acknowledge that the improvement of the arts, and the discovery of new objects of manufacture and commerce, are undoubtedly the finest and most interesting part of chemistry, and which make that science truly valuable; for without these ends what would chemistry be but a science purely theoretical, capable of employing only some abstract and speculative minds, but useless to society? We acknowledge also, that the successes in this kind of chemical inquiry are not rare, and that their authors have sometimes acquired fortunes, so much the more honorable as being the fruits of their talents and industry. But we repeat, that in these researches, the more dazzling and near any success appears, the more circumspection and even distrust is necessary.

CCCCVI. LAC LUNÆ. (d)

CCCCVII. LAC. (e)

CCCCVIII. LAPIS INFERNALIS. See CAUSTIC.

(d) LAC LUNÆ, *Agaricus Mineralis*, is a very light, spongy, friable, and white calcareous earth. See EARTH (CALCAREOUS).

(e) LAC, *Lacca*, or *Gum-lac*, is a kind of wax, of which a species of winged ants form cells upon trees, like honeycombs. In these cells remain some of the dead insects, which give a red color to the whole substance of the lac. That called *stick-lac* is the wax adhering to some of the small branches of the tree, and which is unprepared. This lac, when separated from the adhering sticks, and grossly powdered, and deprived of its color by digestion with menstrua, for the sake of dyes, and other purposes, is called *fixed-lac*; and lastly, when the stick-lac is freed from impurities, by melting it over a gentle fire, and formed into cakes, it is called *shell-lac*. Lac is insoluble in water, and difficultly soluble in

spirit of wine, which for that purpose must be well dephlegmated. According to Neuman, sixteen ounces of seed-lac, distilled in an open fire, yielded nine ounces and six drams of a butter or thick oil, one ounce six drams of a watery liquor neither acid nor alkaline, and a residuum weighing two ounces and a half. It is used in the preparation of spirit varnishes, for the making of staining-wax, and as a coloring material for dyeing leather. The color given by lac is less beautiful, but more durable, than that given by cochineal. To render the coloring matter of the lac dissoluble in water, so as to be applied to the stuffs to be dyed, Mr. Hellot directs the following process: Let some powdered gum-lac be digested during two hours in a decoction of comfrey root, by which a fine crimson color is given to the water, and the gum is rendered pale or

## CCCCIX. LAPIS LAZULI. (f)

CCCCX. LEAD. Lead, called also *Saturn*, is an imperfect metal, white, but darker than tin; the softest, least ductile, least elastic, and least sonorous of all the metals.

It also has the least tenacity; a leaden wire of  $\frac{1}{2}$  of an inch in diameter being capable of supporting only 29  $\frac{1}{2}$  pounds.

This metal has a considerable specific gravity. Next to gold, platina, and mercury, it is the heaviest metal. It loses, when immersed in water, betwixt  $\frac{1}{11}$  and  $\frac{1}{12}$  part of its weight. A cubic foot of lead weighs 848 pounds.

straw-colored. To this tincture, poured off clear, let a solution of alum be added; and when the coloring matter has subsided, let it be separated from the clear liquor, and dried. It will weigh about  $\frac{1}{3}$  of the quantity of lac employed. This dried scedula is to be dissolved or diffused in warm water, and some solution of tin is to be added to it; by which it acquires a vivid scarlet color. This liquor is to be added to a solution of tartar in boiling water; and thus the dye is prepared.

(f) LAPIS LAZULI is a blue stone generally intermixed with white veins and gold-colored spots. Wallerius considers this stone as a species of jasper; and Cronstedt, more justly, as a species of that order of earths which have been lately called zeolites. See ZEOLITES. Mr. Margraaf, and also Mr. Cronstedt, have made experiments on this stone, carefully cleansed from all white, pyritous, or heterogeneous matters. From these experiments we learn, 1. That this stone is soluble in acids without effervescence; and when it has been previously calcined, it forms gelatinous masses with acids. 2. That by calcination it is not deprived of its blue color, till at least that operation has been long continued. 3. By a violent fire it is fusible, and forms a frothy glass, sometimes whitish, and sometimes of a dusky yellow color, but always clouded with blue spots. 4. Fused with nitre, and thrown red-hot into water, it tinged the water with a blue color, which disappeared in some hours. By this operation the stone lost its blue color. 5. Some of this stone, powdered and mixed with glass渣, produced a transparent glass. With borax it produced a chrysolite color. 6. It gave no indication of containing copper, silver,

has been considered as an ore of copper by most authors. 7. It showed marks of iron, by forming a blue precipitate, like Prussian blue, when a phlogisticated alkali was added to a solution of this stone in acids. 8. Margraaf says, that by adding vitriolic acid to solutions of this stone in nitrous and marine acids, a white precipitate was formed, which he supposes was calcareous earth. Nevertheless, Mr. Cronstedt affirms, that this stone does not effervesce with acids. Perhaps the calcareous earth was not essential, but only accidental. 9. Cronstedt says, that a precipitate is formed by adding a fixed alkali to a solution of this stone in vitriolic acid, which, being scorified with borax, yields a regulus of silver. He says, that by scorification with lead, two ounces of silver have been obtained from a hundred pounds of the stone. Mr. Margraaf does not mention that he found any silver, or that he searched for any. Perhaps it is only accidental.

The fine blue substance called *ultramarine* is prepared from lapis lazuli in the following manner, according to Wallerius. The stone, first finely leigared and mixed with linseed oil, is to be added to a paste, made by mixing together equal parts of yellow wax, colophony, pitch, that is, half a pound of each, with half an ounce of linseed oil, two ounces of turpentine, and two ounces of mastic. To three or four parts of this paste one part of the leigared stone, mixed with linseed oil, is to be added; and after the mixture has been digested together during three or four weeks, it is to be thrown into hot-water, and stirred till the blue color separates and dissolves in the water, which is then to be poured off. The blue matter is allowed to settle; and, when dry, is the ultramarine required.



Like all imperfect metals, it has its peculiar smell and taste. When it is cut by a very sharp instrument, its surface appears smooth, compact, and shining; but it quickly tarnishes in the air, and its surface becomes covered by a slight greyish rust. It resists nevertheless much longer than iron or copper the combined action of air and water, before it is decomposed and destroyed. It is very fusible, and melts nearly with the same degree of heat as tin; that is, before it is red.

As soon as it melts, even with the least heat that is requisite, it calcines; and upon its surface greyish ashes are formed, in the same manner as tin is calcined.

The color, softness, fusibility and calcinability of lead being similar to these qualities in tin, persons acquainted with only the common and superficial qualities of metals suppose that a great analogy subsists between lead and tin; nevertheless, we shall show that the properties of these two metals are essentially different.

The grey calx, or ashes of lead, similar externally to those of tin, become of a very different appearance, if the calcination with a fire so moderate that it cannot melt them be continued, and particularly if they be exposed to flame. Instead of becoming more and more white, they acquire at first a yellow color, and are then called *massicot*, or *yellow lead*. The color becomes more and more intense, and at last entirely red. It is then called *minium*, or *red lead*; which see. If instead of calcining this calx with a gentle fire, it be fused, it then easily melts into a yellow vitrified substance, composed of small scales like those of talk. Lead in this state is called *litharge*; see that word. This happens in the operation of *cupellation*. Lastly, if calx of lead be heated more than is necessary to keep it in fusion, it then soon changes into a true glass, which becomes so active and fluid, that it passes like water through the most compact crucibles. Lead thus calcined and melted is called *glass of lead*, because in fact it has the transparency, brittleness, and all the essential properties of glass. It is very useful in many arts, as may be seen under the article GLASS of LEAD.

Of all the metallic calxes, that of lead is the most fusible, and most easily convertible into glass; in which respect it differs essentially from the calx of tin, which is very refractory.

This difference proceeds from the total privation which tin sustains of all its phlogiston, and from its capacity of a radical or perfect calcination. Whereas lead, although it loses, as easily as tin does, as much of its phlogiston as is necessary to destroy its metallic appearance, and so calcine or vitrify it; yet it retains enough of its phlogiston to preserve a great fusibility, and even a considerable density: For all the calxes and glasses of lead are very heavy.

All these calxes and glasses of lead are easily revivable. They can scarcely be melted but some part of the lead is revived, although no inflammable matter has been added. This also is a proof that they retain much phlogiston. For, in general, all metallic calxes are so much more easily reducible as they retain more of their inflammable principle.

Lead is soluble by all acids, and presents with them phenomena similar to those of silver with the same acids. Lead combined to saturation with nitrous acid forms, as silver does, a crystallizable nitrous salt with metallic base, called



called *nitre of lead*. This salt is capable of decrepitating, and even of detonating without addition of inflammable matter, as several chemists pretend. This detonation must therefore proceed from the phlogiston retained by the lead, which is sufficiently combustible for that purpose. Kunkel, who seems not to have known this property of nitre of lead, relates, in his Treatise on the Art of making Glais, that when he attempted to distil this salt, his retort was suddenly burst with great noise and danger.

Several chemists, among others Becker in his Second Supplement to the *Physica Subterranea*, and Kunkel in his *Laboratorium Chemicum*, give processes by which mercury may be obtained from lead. Mr. Grosse, who mentions these processes in the Memoirs of the Academy, gives one himself, which is more simple and more easily tried, since it consists only in saturating perfectly some good nitrous acid with lead. By means of this saturation a grey powder is precipitated, according to this chemist, in which mercury is found. But this process probably does not succeed with every kind of lead; for Messrs. Macquer and Beaume say, in their Course of Chemistry, that they have repeated with all possible attention this experiment of Mr. Grosse, without having obtained mercury.

Pure vitriolic acid, and that contained in neutral vitriolic salts, when mixed with a solution of lead in nitrous acid, unites with the lead, separates it from the nitrous acid, and forms with it a metallic salt, or vitriol of lead, which crystallizes, and appears therefore in form of a white precipitate, when the liquors do not contain a sufficient quantity of water to dissolve it. This salt is the same as that made by dissolving directly lead in vitriolic acid.

Marine acid, and all the neutral salts containing it, precipitate also lead from its solution in nitrous acid, and unite with it, forming a metallic salt called *plumbum corneum*, from the many resemblances that it has with the combination of silver with marine acid, called *luna cornea*. *Plumbum corneum* differs from *luna cornea* in being much more soluble in water, which shews an abundance of marine acid, or that it is less intimately combined in the lead than in the *luna cornea*. *Plumbum corneum* may be made by several other methods, and particularly by disengaging the volatile alkali from sal ammoniac by lead; for, like all other metals, it has the property of decomposing this salt. By this method, Mr. Margraaf makes the *plumbum corneum* which he employs in the preparation of phosphorus.

Several chemists affirm that the solution of lead in nitrous acid may be decomposed by water singly, and that a magistery of lead may be thus formed, in the same manner as that of bismuth. But Mr. Beaume, who has examined the affair with greater accuracy, found that this precipitation does not happen when very pure, that is, distilled water is used; and that consequently this precipitation is to be attributed to the salts, and particularly to the selenites, contained in almost all ordinary waters.

Vegetable acids also dissolve lead with ease; but only the combinations of this metal with vinegar are known, because these are used in medicine and in the arts. The first of these preparations is called *ceruss*, or *white-lead*. It is a kind of salt of lead, of an admirable white color, made by the acid of vinegar, on the vapor of which the lead is exposed. The chief use of this preparation is for painting in oil; and it is the only white hitherto discovered for that purpose, although

although it has two very great faults. The first is, that it gives painful colics to persons employed in its preparation, and the second is, that it is liable to become yellow or black, and, in a word, to lose much of its beauty in time; which proceeds from the disposition which this calx of lead, like all the other preparations of this metal, has to recover its phlogiston, and consequently its color. The discovery therefore of another white, possessed of the beauty and other advantages of white-lead, without its inconveniencies, would be of important service to painting, and even to mankind. *See CRAUS.*

Ceruss contains too little of the acid of vinegar to be in the state of a neutral salt; but as it is lead much opened and divided, it may be easily completely combined to saturation with this acid. For this purpose ceruss must be digested with a sufficient quantity of distilled vinegar, to dissolve it perfectly. The liquor after this solution is called *vinegar of lead*. If it be filtrated, evaporated, and crystallized, fine crystals are formed, capable of a perfect solution in water, of a saline, metallic, and saccharine taste, from which this salt is called *sugar* or *salt of lead*. Salt of lead may be decomposed merely by the action of fire. By distillation a very concentrated acid of vinegar may be obtained from it, a kind of radical vinegar, similar to that obtained from crystals of copper. *See SALT of LEAD.*

Oils and fat matters, which in general are capable of acting upon metallic substances, have a distinguished action upon lead, and particularly upon its calxes. In consequence of this action, ceruss, minium, and litharge, may be entirely and copiously dissolved in most oils by coction with moderate heat. Oils in which lead has been dissolved are thereby rendered thick and drying. Linseed oil thus thickened by lead is much used in painting. The painters call it *drying oil*. So large a quantity of calx of lead may be dissolved in oils, that a body is thence formed, which when cold is solid, tenacious, and of the consistence of plasters. The consistence of many of the plasters used in surgery is caused by calxes of lead dissolved in oils. These masses of lead combined with oil, or plasters, resemble soap in smell, rancid taste, milkiness given to water, and lastly, in being decomposed by acids which unite with the lead, and separate the oil from it. These observations were made by Mr. Geoffroy.

Lead is easily united to sulphur, and is easily burnt and calcined by exposing it at once to the action of sulphur, fire, and air. With sulphur alone it forms a compound resembling the ore of lead, or lead naturally mineralized by sulphur.

This metal easily unites with all metals excepting iron, with which it cannot by any means be alloyed. Such is the antipathy of these two metals, that silver alloyed with some iron be melted with lead, the lead perfectly fuses the silver, and the iron floats upon the surface of the melted metals. Nevertheless the calxes of lead and iron are very well united together by fusion, and the former facilitates the vitrification of the latter as much as it does that of the calxes of other metals. Hence lead may be employed to purify the perfect metals from iron, as well as from other imperfect metals. Of all the alloys of lead, that with tin is most used, being employed for soldering by plumbers, and for tinning. If an alloy of lead and tin be exposed to an open fire, sufficiently strong to make the metal red-hot and to smoke, these two metals will burn and calcine together much

much more quickly and perfectly than either of them would do singly. The calx resulting from this operation is the basis of white enamels, and glazings for earthen ware. It is called *party*.

The affinities of lead, according to Mr. Geoffroy's table, are silver and copper: according to Mr. Gellery's table, they are silver, gold, tin, copper. Iron is marked in this table as being incapable of uniting with lead.

Lead and its several preparations are of great use. It is used and formed into sheets and pipes, for containing and conducting water in buildings and gardens. Lead is not much used in medicine, only externally, from the colics and palsies which it occasions when taken internally. But its external applications are very useful, from its sedative, drying, and repelling qualities. The vinegar and the sugar of lead, also all the ointments and plasters which contain cerus, minium, or litharge, essentially possess these qualities. We have seen that lead is much employed in painting with oil, both as a color and as a dryer. It is also used in the preparation of enamels and of porcelain as a flux, and makes the basis of the glazing of almost all pottery wares from the most ordinary kind to the finest. Lastly, by means of lead, the most perfect metals are refined and assayed. We may therefore say, that this metal is so generally used, and so necessary in the important arts we have mentioned, that they absolutely could not exist without it.

### CCCCXI. L E A T H E R (F O S S I L). (g)

### CCCCXII. L E A V E S. (b)

(g) L E A T H E R (F O S S I L). *Alnus montana*. This is a foliated amianthus, consisting of soft fibres interwoven together. Frequently it contains sparry crystals enclosed in it. For the properties of this stone, see AMIANTHUS.

(b) L E A V E S. The following remarks concerning the coloring substance of leaves are taken from Dr. Lewis. The green color of the leaves of plants may be extracted by rectified spirit of wine and by oils. The spirituous tinctures are generally of a fine deep green, even when the leaves themselves are dull colored, or yellowish, or hoary. The color however seldom remains long in these liquors; and it remains a much shorter time when the coloring matter is separated in a solid form, and exposed to air. The water gives a more durable green color to silk than any other herb. It has been shown that some of the tinctures and of the juices, and acids weaken, destroy, or change them to a brownish color. Acetic acid impairs the color, and also the durability of the color. By means of lime, not insistent green lakes may be obtained from the leaves of *Samolus*, *Ally*, *Ally*, *Ally*, and several other plants. Few herbs communicate any part of their green color

to water; perhaps none give a green considerably deep. Nevertheless a green dye is said to be given to woolen by the leaves of some plants, as of the wild *chervil*, or *cow-wild*, the common *ring-wort*, and *devil's-bit*. The leaves of many kinds of herbs and trees give a yellow dye to wool, previously boiled in a solution of alum and tartar. *Weld* particularly affords a fine yellow dye. Mr. Hellot observes, that all leaves, barks, and roots, which have an astringent taste, as the leaves of the *almond*, *peach*, and *pear* trees, *ash-bark*, *roots of wild paterie*, &c. yield durable yellows. From the leaves of two plants, blue coloring substances are produced, namely, *indigo* and *woad*; which see. Mr. Hellot suspects that a similar blue secula might be produced from many other vegetables. He supposes the green color of vegetables to proceed from a mixture of blue and yellow particles, and that the former are frequently more permanent than the latter; for as to be capable of resisting the fermentation of the juice of the plants, while the yellow are destroyed by that fermentation. Dr. Lewis has tried, without success, to obtain blue dyes from other plants, by putrefying them in water.

CCCCXIII. **LEY (CAUSTIC)**, or the **LEY of SOAP-BOILER S.** This name is given to lixivi-ums of fixed alkali rendered caustic by quicklime. To make these leys, two parts of soda or of potash are mixed with one part of quicklime; or equal parts of alkaline salt ready prepared and quicklime are added together. This mixture is to be put into a large vessel, and 12 or 15 times as much pure water is to be poured upon it, and the quicklime is to be thus slaked: after which the whole is to be boiled during some minutes, and the ley while yet hot is to be filtered through a brown paper filter supported upon linen, and the ley is to be concentrated by evaporation upon the fire, to such a degree as is judged necessary, according to the use for which it is designed.

Quicklime has the property of encreasing considerably the causticity of all fixed alkalis; and this is probably done, not only by taking from them their superabundant inflammable matter, but a part also of that which enters into their composition as a principle. Hence a considerable alteration is produced upon these alkalis by quicklime, similar to that produced upon volatile alkali, and we may consequently decompose entirely all alkalis by quicklime. But these experiments have not been hitherto prosecuted. The properties of fixed alkali rendered caustic have not been sufficiently examined. We know only that by this treatment the dissolving power of alkalis, and particularly upon oily matters, is much encreased; and they are therefore thus prepared, when they are to be combined with oils for the formation of soaps. (i)

The caustic ley, evaporated to dryness, furnishes an alkaline salt exceedingly acrid, which being melted in a crucible becomes what is called *common caustic*; because when it is applied to the skin, it makes an eschar, pierces it, and leaves an ulcer, the suppuration of which, when continued, is called an *issue*.

Caustic alkali has not only much greater dissolving power, but it is also much more deliquescent, and attracts much more powerfully the moisture of the air, than ordinary alkali. These properties must proceed from the development of the saline principle by the quicklime. See **ALKALI**.

CCCCXIV. **LILLY of PARACELSUS.** See **TINCTURE of METALS**.

CCCCXV. **LINNEN (FOSSIL.)** (k)

CCCCXVI. **LIQUOR SILICUM.** **LIQUOR of FLINTS.** The preparation of this liquor consists in uniting by fusion powdered flints or sand with a sufficient quantity of fixed alkali, so that a compound results from it in which the properties of the alkali prevail, and particularly a total solubility in water. For this purpose one part of ground flints or sand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated.

When this mixture has acquired a certain heat, a considerable boiling and swelling are observable, occasioned by the action of these two matters upon

(i) The effect produced upon alkalis by quicklime is the absorption of their fixable air. See **AIR (FIXABLE)** and **ALKALI**. soft fibres, and which has been celebrated for the use it has been applied to, of being woven, and forming an *incombustible cloth*.

(k) **LINNEN (FOSSIL).** Is a kind of Paper has also been made of it, and wicks *amiantus* which consists of flexible, parallel, for lamps. See **AMIANTHUS**.

each

each other. To prevent the matter in this state from flowing over the crucible, this ought to be large, and the fire gradually raised. A part only of the mixture may be put into the crucible at once; and when its effervescence is over, the rest may be added at different times, taking care that each portion to be added be previously heated, to prevent explosion from any moisture which it might contain, when mixed with red-hot melted matter.

When the effervescence of all the mixture is over, it is to be kept in a good fusion during a quarter of an hour, and is then to be poured upon a greased stone or plate of iron. The matter when cold is brittle, and seems vitrified. It is even transparent like glass, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and strongly attracts moisture from the air, and is entirely soluble in water, except a very small portion of earthy matter. But a similar earth is also always separated from pure fixed alkali during its solution in water.

The filtrated solution is at first clear, and limpid; but it afterwards becomes turbid, and forms an earthy sediment, like that formed by solutions of fixed alkali, only the former seems more copious. This liquor has all the properties of liquid fixed alkali.

All these properties of alkaline salts, and particularly its total solubility in water, are caused by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the composition of any body do also predominate in that body, we may perceive why the properties of the fixed alkali in the present combination should be more sensible than those of the earthy matter or flints. The alkali communicates to the earthy matter some of its strong disposition to unite with water. The flints are really kept dissolved in water, and by this experiment they are consequently reduced into a liquor, and hence it has been called the *liquor of flints*. If any acid be added to the liquor of flints so as to saturate the alkali, the flint which was kept dissolved in water by means of this alkali will be now precipitated in state of a fine earth. Mr. Pott mentions a very singular phenomenon which happens in this experiment, which is, that this earthy precipitate is entirely soluble by acids; so that if more acid be added than is sufficient to saturate the alkali, the precipitate will entirely disappear.

As vitrifiable earths in their natural state, and even when divided as much as is possible by mechanical methods, are insoluble in acids, and as they become soluble by acids, when they have been combined by fusion with a sufficient quantity of fixed alkali, they must consequently undergo a singular alteration in this operation. This property which they acquire of dissolving in acids, proceeds either from the great fineness to which their parts are reduced, or from a small portion of fixed alkali, or from some of its principles which remain united with them, and from which they cannot be entirely separated by the precipitating acid.

The fixed alkali which enters into this combination receives also some alteration from the vitrifiable earth, one part of it is decomposed, and its earthy precipitated with the vitrifiable earth, and the remaining part is rendered much more caustic than it was before.

In vitrifications something happens similar to what is observed in the compound designed to make the liquor of flints. The glasses which contain too

much alkaline salt in their composition, or which have not sustained a long or strong enough fire to unite the earth intimately with the fixed alkali, are partly soluble in acids, have sometimes even an alkaline taste, tarnish, and moisten in the air. See VITRIFICATION.

**CCCCXVI. LIQUOR, or SPIRIT (SMOKING) of LIBAVIUS.** This preparation is a marine acid very concentrated, smoking, and impregnated with much tin. It is obtained by distillation from a mixture of corrosive sublimate with tin.

To make the smoking liquor of Libavius, an amalgam must be made of four parts of tin and five parts of mercury: this amalgam is to be well mixed with an equal weight of corrosive sublimate, by trituration the whole together in a glass mortar. This mixture is to be put into a glass retort, which is to be placed in a reverberatory furnace. To the retort is to be luted with fat lute a receiver with a small hole in it, in the same manner as is done for the distillation of concentrated mineral acids. The distillation is then to be begun with a graduated and well managed fire. A very smoking liquor passes into the receiver, and towards the end of the distillation a very thick and even concrete matter. When the operation is finished, the liquor in the receiver is to be poured quickly into a crystal glass bottle with a glass stopper. When this bottle is opened, a white, copious, thick, and poignant fume issues, which remains long in the air without disappearing.

The very concentrated marine acid contained in the corrosive sublimate quits the mercury in this experiment to unite with the tin; and as this acid has the property of raising with it in distillation most metallic matters, a considerable quantity of the tin passes over in this distillation. Nevertheless this acid is far from being saturated with tin; it is still very acid, and capable of dissolving much tin in the ordinary way. From this imperfect saturation, together with its great concentration, proceeds partly its property of smoking so considerably. Nevertheless some other cause probably concurs to give it this property. For although this liquor smokes infinitely more than the most concentrated spirit of salt, distilled in Glauber's manner, its vapors are notwithstanding much less elastic. Another very essential difference betwixt this liquor and concentrated spirit of salt is, that by mixing the former, but not the latter, with spirit of wine, marine ether may be obtained. See ETHER (MARINE).

Lastly, if we attempt to dissolve, by the ordinary method, as much tin in concentrated spirit of salt as is contained in the smoking liquor of Libavius, this acid, so far from being thereby rendered more smoking, ceases entirely to smoke. A real difference therefore subsists betwixt the marine acid impregnated with tin by the decomposition of corrosive sublimate, and by distillation, and the marine acid treated with tin in any other manner. But we cannot easily determine whence this difference proceeds. Does this acid deposit in the mercury or in the tin some of its principles? If that be the case, with what principle is tin impregnated in this experiment? Is it with phlogiston? or with mercurial earth? These questions cannot be decided without further researches.

The smoking liquor has all the other properties of the most concentrated marine acid, when imperfectly saturated with tin. If it be diluted with much water, most of its tin will be separated from it in the form of white light fumes.



when it is mixed with a solution of gold in aqua regia, it forms the purple precipitate of Cassius, as all other solutions of tin, and even pure tin not dissolved, do. See PRECIPITATE (PURPLE) of CASSIUS. It may be precipitated by absorbent earths, and by alkaline salts. In several dyes, particularly in those which are red, it produces the same effects as tin dissolved by marine acid. See DYEING.

The necessary management for making the smoking spirit of Libavius is not very troublesome or difficult. This operation is much easier than the distillation of very smoking spirit of salt by means of vitriolic acid, from the greater elasticity and expansive force of the vapors of the latter.

For the distillation of the smoking spirit of Libavius, the tin is previously amalgamated with mercury, because in this state it is much more easily miscible with corrosive sublimate. If the distillation be continued, and the heat increased, after the butter of tin, or the concrete part of the combination of tin with marine acid, has risen, the mercury revived from the corrosive sublimate may be obtained. See ACID (MARINE), TIN, MERCURY, and CORROSIVE SUBLIMATE.

CCCCXVII. LIQUOR (MINERAL ANODYNE) of HOFFMAN. This composition, which is used in medicine only, is a mixture of very rectified spirit of wine, of ether, and of a little of the sweet oil of vitriol. This liquor is made by mixing an ounce of the spirit of wine which rises first in the distillation of ether, with as much of the liquor, and afterwards by dissolving in this mixture, which rises next, and which contains the ether, twelve drops of the oil which rises after the ether has passed. This is what is called the mineral anodyne liquor of Hoffman. It has precisely the same virtues as the ether, which physicians now begin to substitute for it. As ether and oil of spirit of wine is now made from the nitrous, marine, and acetous acids, liquors may be made from these, in imitation of that of Hoffman from the vitriolic acid. See ETHERS.

CCCCXVIII. LITHARGE. Litharge is lead deprived of great part of its phlogiston by fire, and is in a state of imperfect vitrification.

When silver is refined by cupellation with lead, this latter metal, which is scorified, and causes the scorification of the imperfect metals alloyed with the silver, is transformed into a matter composed of small semi-transparent shining plates, resembling mica; which is litharge. Litharge is more or less white or red, according to the metals with which the silver was alloyed. The white is called *litharge of silver*, and the red is called *litharge of gold*.

Litharge may be easily revived into lead, accordingly much of that which is produced by refining in great is reduced, by being melted upon burning coals. The part of it which is least altered by mixture with other metals is thus reduced, and by this method good and saleable lead is obtained. The rest of the litharge of these refineries is sold and used for various purposes. Pottery uses much of it for glazing their ware. It is employed for the fusion of some plasters, and other external remedies; and also in painting under linseed oil drying. Lastly, it is added in the composition of glass, for it is very fusible, and assists the fusion of other substances. It has in general the same properties as the other oxides of lead. All the litharge which is commonly sold comes from refineries. The quantity formed there is more than

is sufficient for the demand, and therefore it is not prepared purposely. See *REFINING and LEAD*.

**CCCCXIX. L I V E R of A N T I M O N Y.** Liver of antimony results from the detonation of antimony with an equal weight of nitre. These two matters reduced into powder are to be mixed together, and put into a large crucible. The matter is then to be kindled, and the detonation to be made. When it has detonated, it is to be kept in fusion and then cooled. When the crucible is broken, at the bottom two distinct matters are found, which may be separated from each other by the stroke of a hammer. The upper matter is a saline scoria, nearly of the same nature as the scoria of the regulus of antimony. This is a true antimoniated liver of sulphur, mixed with a certain quantity of vitriolated tartar. The lower matter is heavier. It is opaque, compact, red, and brittle. This is the liver of antimony. Its color and appearance have been supposed similar to those of the livers of animals, and thence it has received its name.

Liver of antimony is principally composed of the metallic part of antimony, half deprived of its sulphur, and dephlogisticated by nitre.

Some chemists consider the liver of antimony as an antimoniated liver of sulphur. Others affirm, that it is only the metallic earth of antimony, melted, by means of a remaining part of sulphur and phlogiston, into a substance the nature of which is intermediate betwixt those of antimony and of glass of antimony. It may possibly be sometimes in one state, and sometimes in the other, according as the matter has been more or less long in the fire, and more or less well fused. The true nature of this substance may easily be ascertained by a proper examination. But this preparation, which was considered as important when antimonial remedies were first introduced, deserves at present little notice. For it is not of any use in what is properly called Chemistry; and it is no longer employed in Medicine, since kermes mineral and emetic tartar have been introduced, which are remedies superior to all other antimonials from the certainty of their effects, when they are well prepared, and by which all the effects obtainable by any preparation of antimony may be obtained, by giving them separately or conjunctly in different proportions, according to the indications to be answered. See *ANTIMONY, KERMES MINERAL, and TARTAR (EMETIC)*.

**CCCCXX. L I V E R of A R S E N I C.** Liver of arsenic is a combination of white arsenic with liquid fixed vegetable alkali, or by the humid way. Arsenic has in general a strong disposition to unite with alkalis. Mr. Macquer, in his Memoirs upon Arsenic, mentions a singular kind of neutral salt, which results from the union of arsenic with the alkaline basis of nitre, when nitre is decomposed, and its acid is disengaged in close vessels, by means of arsenic. To this salt he has given the name of *neutral arsenical salt*. See that article. The liver of arsenic mentioned also by that chemist, although composed, like the neutral arsenical salt, of arsenic and fixed alkali, is nevertheless very different from the

The operation for making liver of arsenic is easy and simple. To strong and concentrated liquid fixed alkali, previously heated, fine powder of white arsenic must be added. This arsenic easily disappears and dissolves, and as much of it is to be added till the alkali is saturated, or has lost its alkaline properties, although



although it is still capable of dissolving more arsenic superabundantly. While the alkali dissolves the arsenic in this operation, it acquires a brownish color, and a singular and disagreeable smell, which however is not the smell of pure arsenic heated and volatilised. Lastly, this mixture becomes more and more thick, and at length of a gluey consistence. This matter is not crystallizable as the neutral arsenical salt is. It is easily decomposed by the action of fire, which separates the arsenic. This does not happen to the arsenical salt. Lastly, any pure acid is capable of separating arsenic from the liver of arsenic, in the same manner as they separate sulphur from liver of sulphur: whereas the neutral arsenical salt cannot be decomposed but by means of the united affinities of acids and metallic substances. Thus we see that arsenic may be combined with fixed alkali in two very different manners.

The author has given to this combination the name of *liver of arsenic*, to distinguish it from the neutral arsenical salt, and in imitation of the name of the *liver of sulphur*, given to the combination of the fixed alkali with sulphur. See ARSENIC and NEUTRAL ARSENICAL SALT.

CCCCXXI. LIVER of SULPHUR. The liver of sulphur is the combination of sulphur with alkaline matters. Ordinary liver of sulphur, or the combination of sulphur with fixed alkali, may be made either in the dry or humid way.

To make liver of sulphur by the dry way, or by fusion, equal parts of fixed alkali and sulphur are mixed together. This mixture is to be put into a crucible, and it is to be quickly fused to avoid the dissipation and combustion of the sulphur. A strong heat, however, is not necessary, because the sulphur easily melts and facilitates the fusion of the alkali. When this mixture is perfectly fused, it is to be poured upon a greased stone, and then the liver of sulphur congeals and acquires a brown color. If it be required to be kept dry, it must be quickly broken in pieces, and put while it is yet hot into a bottle which is to be well corked, because it readily imbibes moisture from the air.

To make liver of sulphur in the humid way, concentrated liquid fixed alkali and fine powder of sulphur are to be boiled together, till the alkali has dissolved all that it can: the liquor is then to be filtrated and evaporated. This second method of making liver of sulphur is not much used, because it is longer and less advantageous than the former.

Liver of sulphur is an important combination in chemistry, because it is in general a very powerful solvent. This compound partakes, according to the general rule, of the properties of the two substances which enter into its combination. The sulphur, by its union with the alkali, appears less volatile, less combustible than when alone, and may be entirely dissolved in water by the intervention of this alkali; and also this alkali, saturated with sulphur, shews less of its alkaline properties.

As sulphur is composed of variolic acid and phlogiston, we may doubt to which of these its union with the fixed alkali is to be attributed. But if we attend to the properties of liver of sulphur, we shall perceive that the sulphur is in all its substance combined with the alkali, and adheres to it by both its principles. In fact, if we dissolve liver of sulphur in water, and pour into this solution any acid, the liver of sulphur will be instantly decomposed by this acid, which will unite with the alkali, and separate from it the sulphur in form of a white

white powder: but this powder, when dried and examined, appears to be sulphur, such as it was before.

Although vitriolic acid which is contained in sulphur be in general the strongest acid, the sulphur is nevertheless separated from the alkali by any acid, even by the weakest, as vinegar. This phenomenon is another proof of what we have advanced concerning the manner in which sulphur is combined with alkali; for if the union of the inflammable principle of the sulphur did not considerably oppose the adhesion which the acid of this sulphur is capable of contracting with fixed alkali, the weaker acids certainly could not separate it. These effects may be explained by this general principle, that the less simple any bodies are, the less strongly they are capable of adhering to other bodies.

The liver of sulphur exhibits also another phenomenon worthy of attention, and which depends also, as we shall see, on the same principle. It is, that the connexion betwixt the phlogiston and the acid is much less in sulphur united to an alkali than in pure sulphur. This is proved by the smell of the liver of sulphur, which is very strong and very fetid, even when it is not heated; while sulphur, not heated, has scarcely any smell.

This smell of the liver of sulphur, which resembles much the smell of eggs beginning to putrify, becomes much stronger when it is decomposed by an acid. It is certainly occasioned by an evaporation of part of the phlogiston of the sulphur; for it produces exactly all the effects of the inflammable principle when reduced into vapor, or when it disengages itself from bodies without burning. It particularly affects the brain and nervous system, and causes stupefaction, intoxication, syncopes, and when in large quantity is even capable of instantly killing men and animals. These are the same effects which are produced by the vapors of charcoal, and of substances undergoing the spirituous or putrid fermentations. Mr. Cartheuser, talking of the manner of decomposing sulphur with alkali, to obtain from it the acid without sensible combustion, according to Stahl's process, expressly remarks, that the vapor which exhales during this operation affects the head, and causes stupefaction. I know a chemist who, when he was decomposing at once a large quantity of liver of sulphur by an acid, was struck by the vapor so as to fall down and faint.

Further, the emanations of liver of sulphur, which are nothing else than pure phlogiston reduced into vapor, and which must be distinguished from the vapor of burning sulphur, which is phlogisticated vitriolic acid; these emanations, I say, of liver of sulphur are easily applied to any body capable of receiving the inflammable principle, and combine more or less intimately with these bodies, according to their nature and actual state. If silver, for example, be exposed to the vapor of liver of sulphur, or if it be immersed in a heated solution of liver of sulphur, the surface of this metal becomes tarnished and blackened by the phlogistic emanations, with which it readily is impregnated superabundantly. Also, if solutions of silver, mercury, lead, or bismuth, be precipitated by liver of sulphur, all these precipitates, instead of being white, as they would have been if a pure alkali had been used, are rendered brown, black, or leaden-colored, by the phlogiston which attaches itself to them: hence solutions of these metals become sympathetic tinks, which may be rendered visible by liver of sulphur, or by its vapor; and hence liver of sulphur may be successfully employed to discover lead contained in adulterated wine;

wine; and reciprocally, these metals, their solutions or calxes, may be properly applied to discover sulphur in mineral waters or other liquors. *See* **INK** (**SYMPATHETIC**), **WATERS** (**MINERAL**), *and* **WINE**.

We must observe, that in this application of the phlogiston of liver of sulphur to most metallic calxes, this phlogiston, although transmitted either in vapor, or by the humid way without fusion, combines nevertheless so intimately with these metallic earths as to revive them, and to restore to them all their metallic properties. This truth, though long ago known to chemists, was alluded to by Mr. Rouelle the younger, who, in the *Medical Gazette*, proposes this reduction in form of a problem, as a very great novelty. The chemist who replied, judiciously used litharge to make this reduction visible; because this preparation of lead being in molecules or scales, which present surfaces very smooth and sufficiently large, is very proper to shew the metallic color and brilliancy which the litharge instantly assumes, when it is immersed even in a cold solution of liver of sulphur. *See* **REDUCTION**.

All these properties of liver of sulphur shew very clearly, that the adhesion of the phlogiston to the acid in sulphur is greatly diminished by the union of sulphur with alkali; and as the phlogiston is infinitely more volatile than the acid, it may therefore be more easily separated from the liver of sulphur. The smell and emanations of liver of sulphur shew, that its inflammable principle is continually dissipating. We may therefore consider sulphur, formed into liver of sulphur, as gradually decomposing, particularly when it is dissolved in water. Accordingly, if we preserve liquid liver of sulphur in an open vessel, the quantity of sulphur diminishes more and more, and the liver of sulphur gradually changes into vitriolated tartar.

We may form an explanation of this diminution of the connexion of the principles of sulphur in the liver of sulphur, if we suppose that all bodies have only a certain determinate degree of force by which they adhere to each other; which is very probable, and is even shewn by all the phenomena of chemistry; and if we suppose, in the second place, that in sulphur the phlogiston and acid have exhausted upon each other all their force of tendency or of combination. Upon these suppositions, these two principles are either incapable of combining with a third body, as with the alkali; or if they combine with it, this new union must lessen the force of the former union; and this accordingly appears to be the reason why the simplest bodies are those which contract the strongest union. *See* **AFFINITY**, **AGGREGATION**, **COMBINATION**, *and* **SOLUTION**.

Liver of sulphur is a great solvent of metallic matters; all which, excepting zinc, it attacks, particularly in fusion. It seems to dissolve gold more effectually than other metals. *See* **GOLD**. This compound dissolves also vegetable coals, even by the humid way, according to the observation of Mr. Rouelle the younger. This solution is of a green color; and when liver of sulphur has dissolved charcoal by fusion, it becomes of a much deeper red color than when pure, as may be observed in the making of artificial sulphur in Stahl's manner.

Particular kinds of liver of sulphur may be formed by the combination of volatile alkali, of quicklime, or of absorbent earths, all which attack sulphur more or less. The properties of these livers of sulphur may be referred to those of the

the ordinary one; but they have not been examined so much as they ought to be. See SULPHUR.

CCCCXXII. LIXIVIAL. Those salts are called lixivial which have been extracted by lixiviation, and these chiefly are fixed alkalis; which are therefore called *lixivial salts*. See ALKALI.

CCCCXXIII. LUNA CORNEA. This name is given to the combination of marine acid with silver. Marine acid has in general a great affinity with metals, and particularly with those called *white*, or *lunar*, or *mercurial metals*. Of these silver is the chief. Marine acid can scarcely dissolve these metals in the ordinary methods. They must be generally much divided, or the acid must be much concentrated, reduced into vapors, and assisted with a considerable degree of heat, to accomplish the solution. This is particularly true as to silver and mercury. But when these metals are previously dissolved in nitrous acid, then the marine acid, which has a stronger affinity with them than the nitrous has, seizes them quickly, separates them from the nitrous acid, and forms with them a new combination.

To make this combination with silver, it is first dissolved in nitrous acid. To this solution marine acid, or more commonly common salt dissolved in water, is to be added. The mixture soon becomes turbid, and in it a copious precipitate is formed, which has always the appearance of curd. The solution of salt is thus added till no more precipitate is formed. The precipitate, when separated from the supernatant liquor, is called *luna cornea*.

Marine acid has so great an affinity with silver, that it overcharges itself in some measure with the metal in this precipitation. Luna cornea is much less soluble in water than the combinations of other metals with this acid. This little solubility of luna cornea is the cause of its appearing in the form of a precipitate.

The adhesion of the marine acid with silver is very strong in luna cornea. If this matter be exposed alone to fire, the acid carries off with it a portion of the silver, although this metal be very fixed. The remaining matter melts, and takes the form of a horn-like substance, as all chemists say; and hence it has been called luna cornea. Some differences must occur in combining marine acid with silver, according to the manner in which it is done, and particularly according to the proportion of the two substances.

Luna cornea is not employed either in medicine or in the arts (*1*); and is even little used in chemistry, excepting for particular operations and researches. This precipitation is very convenient, for example, in the examination of mineral waters, or of any other liquor, to discover if they contain marine acid in whatever base it be engaged, excepting metallic bases; for if these waters contain the smallest quantity of marine acid, a luna cornea will be precipitated by

(1) Luna cornea mixed with sea-salt and tartar rubbed on brass, gives a silver-like appearance; and is the substance employed for the silvering of the dial-plates for clocks. A more substantial silvering may be given by the above mixture, if the piece of brass to be silvered be previously heated considerably, and cleaned with a scratch-brush, and if the operation be repeated till the silver seems to be sufficiently thick. The brass, having a stronger disposition to unite with the marine acid than the silver has, separates it from this latter metal, which is then precipitated upon the surface of the brass plate.

them

them from a solution of silver in nitrous acid, and this luna cornea is easily known by its curd-like appearance. See WATERS (MINERAL).

We may easily perceive that when the marine acid, which forms the luna cornea, is engaged in a basis, it must quit its basis to combine with the silver; and then the nitrous acid, which was united with the silver, is now disengaged, and joins itself to the substance with which the marine acid was first united; so that two decompositions take place, from which two combinations result. Thus, when luna cornea is made with a solution of common salt, the liquor after the operation contains some cubic nitre; and if marine salt with an earthy basis was used, it would be transformed, in this operation, into a nitre with an earthy basis.

The best method of separating silver from marine acid, or, as the chemists say, of reducing luna cornea, is to mix it very accurately, and to melt it in a crucible, with a very large quantity of some fixed alkali: but the heat must be very gradually applied till the ebullition and swelling, which are caused by the action of the fixed alkali and marine acid, have ceased; then the heat is to be encreased, and the matter is to be thoroughly fused; after which, the silver is found revived at the bottom of the crucible. This silver is justly esteemed to be the purest of all, when the several operations have been well made. But the luna cornea cannot easily be reduced without loss; because it is apt to evaporate partly, and even to pass through crucibles. See ACID (MARINE), and SILVER \*.

CCCCXXIV. L U T E. In many chemical operations, the vessels must be covered with something to preserve them from the violence of the fire, from being broken or melted, and also to close exactly their joinings to each other, to retain the substances which they contain, when they are volatile and reduced to vapor. For this purpose, several matters are employed, called in general *lutes*.

The lutes with which glass and earthen-ware retorts are covered ought to be composed of nearly equal parts of coarse sand and refractory clay. These matters are to be well mixed with water and a little hair, so as to form a liquid paste, with which vessels are to be covered, layer upon layer, till it is of the required thickness.

The sand mixed with the clay is necessary in this lute, to prevent the cracks which are occasioned by the contracting of clay during its drying, which it always does when it is pure. The hair serves also to bind the parts of the lute,

\* Mr. Margraaf has made experiments to discover the best method of reducing luna cornea, which he found to be the following: Dissolve half an ounce of fine silver in aqua fortis, precipitate it by sea-salt, and edulcorate the precipitate, which will then weigh five drams and sixteen grains. For the reduction of this precipitate, mix it with an ounce and a half of dry volatile sal ammoniac, triturate them well together with a little water during a quarter of an hour; then add three ounces of mercury obtained from cinnabar by means of quicklime, and continue to triturate during some hours with a little more water. Thus an amalgam will be formed, which being washed from a white powder and dried, will weigh three ounces and half a dram. By distillation of this amalgam, a residuum of silver, four grains less than the original half-ounce, will be obtained. By subliming the white powder, which weighs five drams, three grains of silver will be obtained: but if the amalgam and white powder be together distilled, the operation will fail, and the luna cornea be recomposed. See BERLIN MEMOIRS, 1749.

and to keep it applied to the vessel: for, notwithstanding the sand which is introduced into it, some cracks are always formed, which occasion pieces of it to tumble off.

The lutes with which the joinings of vessel are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapors of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flour-paste. In such cases also slips of wet bladder are very conveniently used.

When more penetrating and dissolving vapors are to be contained, a lute is to be employed of quicklime slaked in the air, and beat into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which is to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm.

Lastly, when saline, acid, and corrosive vapors are to be contained, we must then have recourse to the lute called *fat lute*. This lute is made by forming into a paste some dried clay, finely powdered, sifted through a filken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with pack-thread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

## M.

CCCCXXV. **M A C E R A T I O N.** Maceration is the steeping of bodies in a cold liquor, to soften, penetrate, and open them; or even to dissolve some principle of them. This operation is essentially the same as digestion, and only differs in this, that it requires no more than the heat of the atmosphere. Maceration is preferable to digestion, whenever heat is useless or hurtful to the operation. For instance, when hard and woody aromatic vegetable matters are to be steeped, with intention to soften and open them, to extract afterwards more easily from them their essential oil, they ought to be macerated without heat, and not digested, considering that the smallest heat is capable of dissipating a great part of the spiritus rector, which ought always to be preserved as much as is possible, since it ameliorates the essential oil, and encreases its quantity.

CCCCXXVI. **M A D D E R.** (*m*)

CCCCXXVII. **M A G I S T E R Y.** This name is given to almost all precipitates. Thus magistery and precipitate are frequently synonymous: but lately chemists have chiefly used the term precipitate, and applied that of magistery to some particular precipitates only, which are used in medicine and in the arts. Such are the magisteries of bismuth, coral, crabs-eyes, sulphur, &c. See **PRECIPITATION** and **PRECIPITATE**.

CCCCXXVIII. **M A G I S T E R Y of B I S M U T H.** The magistery of bismuth is the calx of that semi-metal, separated from the nitrous acid by water alone, and well washed.

To make this preparation, very pure bismuth must be dissolved in nitrous acid, which must also be very pure. To this solution when a very large quantity of clear water is added, the whole is rendered turbid and milky, and a

(*m*) **MADDER.** The root of madder impregnates water with a dull red color, and spirit of wine with a deep bright red. This root, when eat by animals along with their food, tinges their urine, and their most solid bones, of a deep red. Wool, previously boiled in a solution of alum and tartar, receives from a hot decoction of madder and tartar a very durable, but not a very beautiful red color.

very beautiful and shining white sediment is afterwards formed. The supernatant liquor is then to be decanted; the sediment is to be put upon a paper filter, and more pure water is to be added, till it comes off quite insipid. The sediment, which is the magistery of bismuth, ought to be carefully dried, and kept in a well closed bottle.

Bismuth is one of those metallic substances which are partly separated from acids by dilution with much water, and which cannot be kept dissolved but by acids concentrated to a certain point, or when the acid is more than is sufficient to saturate the metal. By the dilution of the acid, then, this operation is performed. The precipitate is very white; both because a small portion of acid remains united with it, which the water cannot take from it, and because the nitrous acid has taken from the bismuth most of its phlogiston.

As bismuth resembles lead in many of its properties, some chemists observing that by mixing a solution of common salt with a solution of bismuth in the nitrous acid, a white precipitate is formed, which also happens to solutions of silver and of lead, believed that in this precipitation the marine acid united with the bismuth, and formed a *bismuthum corneum*. But Mr. Pott, although he had been himself of this opinion, has shewn that the precipitation is caused merely by the water in which the common salt is dissolved; since, when the solutions of bismuth and of common salt contain the smallest possible quantity of water, no precipitation results from their mixture. Bismuth, therefore, differs essentially from lead in this respect.

The chief use of the magistery of bismuth is to enter into the composition of white paint used by ladies. It is preferred to all other whites from its superior beauty, its lustre, and an almost insensible tint of carnation, which renders it more similar to the finest and whitest skin.

This advantage, which is very great, is counterbalanced by great faults. The skin is said to be considerably spoiled by a continued use of it; it is also very apt to acquire a blackish color. Metallic substances and their calxes are known to be very apt to be impregnated with phlogiston, when it touches them while it is in vapor, or in any other state favorable to combination. By this means, whether they recover a part of the phlogiston of which they have been deprived, or whether they receive it superabundantly, they always acquire dark and blackish tints. But of all metallic calxes, that of bismuth is one of the most susceptible of this effect: its fine white becomes brown, and even leaden-colored, by a very slight exposition to the phlogistic vapors; such as the exhalations from houses of office, from garlic, eggs, and particularly from liver of sulphur. For this reason the white of bismuth must be kept in well closed bottles, otherwise it would be injured by circulating vapors which pervade paper coverings. From this property of bismuth, it is rendered capable of affording a kind of sympathetic ink. See *INK (SYMPATHETIC)*.

Some artists prepare magistery of bismuth by precipitating it from its solution in the nitrous acid, by a fixed alkali. But this method does not produce so good a white as the precipitation by water alone. The cause of this also is, that the calx of bismuth very easily recovers its phlogiston. Alkalis, however pure, always contain some superabundant inflammable matter, and apply it to the metallic calxes which are precipitated, and particularly to the calx of bismuth,



bismuth, which becomes more brown in proportion to the greater quantity which it takes of this inflammable matter. *See BISMUTH.*

CCCCXXIX. **MAGISTER Y of CORAL, CRABS-EYES, &c.** Coral, crabs-eyes, pearl, shells, chalk, and other substances of that kind, are all absorbent and calcareous earths, easily soluble in nitrous acid, with which they form a nitre with an earthy basis. If the solutions of these matters be treated like the mother-water of nitre; that is, if they are precipitated by a fixed alkali, and afterwards well washed, all these earths will be obtained in a very divided state. The name of magistery is then given to them, together with the name of the substance which has been dissolved and precipitated. All these magisteries are nothing else but absorbent earths, which differ little from each other, or from magnesia. For the method of preparing these magisteries *see MAGNESIA.*

CCCCXXX. **MAGNESIA ALBA.** Magnesia is a white earth precipitated from the mother-waters of nitre and of common salt by a fixed alkali. It ought afterwards to be welledulcorated, to deprive it of all the saline particles it might retain.

To make magnesia, the mother-water of nitre, or of common salt, is placed in a large vessel, and diluted with a considerable quantity of common water; then a liquid fixed alkali is gradually poured upon it, and the mixture is to be agitated, which presently becomes turbid, and of a white milky color. In this manner alkali is to be added at different times, till no more precipitate is perceived; the liquor is to be further diluted with common water, if that be necessary for facilitating the earthy sediment: when this sediment is all formed, the liquor is to be decanted from it: it is then to be poured upon a filter of brown paper, supported by a cloth: pure water is poured upon it, till it is no longer capable of giving any taste to the water: the earth is then to be formed into troches or cakes, and left to dry. This is *magnesia*.

The mother-waters of nitre and of common salt are almost entirely composed, the former of nitre and sea-salt with earthy bases, and the latter of sea-salt with an earthy basis. *See WATERS (MOTHER), NITRE, NITRE with EARTHY BASIS, WATER of the SEA and SALT FOUNTAINS, SALT (COMMON), SALT (SEA) with EARTHY BASIS.* These salts are composed of nitrous and marine acids saturated with a calcareous earth, and are very deliquescent. They therefore do not crystallize; and great quantities of them remain dissolved in the last portions of liquor from which no more crystals can be obtained. Fixed alkalis being capable of decomposing all salts with earthy bases, and of separating their earth, do actually separate it in the present operation. Magnesia is then nothing else than a very much divided calcareous earth. It is employed in medicine as an absorbent earth, and is a very good one, from the fineness of its parts.

The mother-waters from which magnesia is to be precipitated, must necessarily be diluted in a very large quantity of water, because the absorbent earth dissolved by the nitrous and marine acids, is there in so large a quantity, that when an alkali is added to it without dilution, no precipitation seems at first to take place. The molecules of earth, not being capable of moving freely and of joining each other, do not form sensible molecules, and remain almost in the same state in which they were when they adhered to acids. But the separ-

ration is nevertheless made, and so copiously, that the water of the mixture is found to be in too small a quantity, and that the whole becomes solid. This almost solid coagulation, which happens when two very fluid liquors are mixed, astonishes persons who do not understand the reason of it. It has accordingly been called the chemical miracle, *miraculum chemicum*. To prevent this coagulation, and to allow the earth to deposit itself, a sufficient quantity of water must be added.

After the precipitation is made, neutral salts with bases of fixed alkali remain in the liquor, which differ according to the kinds of acids which formed the salts with earthy bases, and according to the nature of the alkali employed for this decomposition. Thus, if the mineral fixed alkali had been employed, the neutral salt formed in the mother-water of sea-salt will be common salt, and the neutral salt formed by that alkali in the mother-water of nitre will be cubic nitre. If a fixed vegetable alkali has been employed, from the mother-water of common salt, the febrifugal salt of Sylvius may be obtained; and from the mother-water of nitre, not only that febrifugal salt, but also ordinary nitre may be obtained.

Hence, if magnesia be made in a very large quantity, the water, after the precipitate has been procured, ought not to be thrown away; as from it much good nitre and common salt may be obtained, according to the kind of mother-water employed. To obtain nitre, fixed vegetable alkali ought to be used; and to obtain common salt, the mineral alkali: the liquor is then to be evaporated, and crystals of these salts will be formed.

If the magnesia is not washed, it contains much of these salts. In that case, it would not be a simple absorbent, but would partake of the virtues of these salts. It would even be purgative in a certain dose: but as the quantity of salts which remains is always uncertain, when we intend that the magnesia shall contain any, it ought to be prepared in the ordinary method, and afterwards such doses of these salts as we shall judge proper may be added to it.

Some artists prepare magnesia without precipitation by an alkali. Their method is by evaporating the mother-water, and calcining the residuum in a crucible, to dissipate the acids: but this method is improper, because the magnesia by calcination acquires the property of quicklime.

If, instead of pouring fixed alkali into the mother-water, vitriolic acid be mixed with it, and if the mother-water has not been diluted with common water, a large quantity of a very white precipitate will be formed in it. Some authors have improperly called this precipitate magnesia; but it is of a very different nature from the earth properly so called. (n)

(n) This substance, distinguished by the name *magnesia alba*, from the dark-colored mineral called also *magnesia*, or *manganese*, has been accurately examined by Dr. Black. The experiments of that excellent chemist on this subject are related in the second vol. of the *Essays Philosophical and Literary*, published at Edinburgh. From these we learn the following results: 1. Magnesia is soluble with effervescence in vitriolic, nitrous, ma-

rine, and acetous acids. With vitriolic acid it formed crystals similar in all respects to those of the salt called *Epsom-salt*. With nitrous acid it formed crystals, which deliquesced in a moist air. With marine acid it did not form crystals; but the saline matter being evaporated to dryness, soon deliquesced by exposure to air. With distilled vinegar it formed no crystals by evaporation; but a saline mass, which, when warm,

The sediment formed by adding vitriolic acid, far from being a pure calcareous earth, consists of that earth which this acid takes from the nitrous and marine acids, and forms with it a selenites. This selenites appears as a precipitate; because, as it is very little soluble in water, it cannot be all suspended or dissolved in the liquor: but if a large quantity of water, especially hot water, be added, this pretended magnesia either does not appear, or afterwards disappears by being again dissolved. This precipitate is not applied to any use. See SELENITES.

# CCCCXXXI. M A G N E S I A. (o)

warm, was viscid, resembling glue in color and consistence, and when cold, was brittle. 2. By calcination, it lost  $\frac{1}{2}$  of its weight. When calcined, it did not effervesce with acids, whence the substance lost by calcination was chiefly fixable air. This air, and almost all its weight lost by calcination, was restored to it by solution in vitriolic acid, and precipitation from thence by a mild fixed alkali, the air of which it absorbed. 3. By the last mentioned properties (2) it seemed analogous to calcareous earths, but differed from these earths, in the nature of the salts formed by it with acids (1), and also in other properties; but especially in this, that even when calcined, it was not soluble in water. The Author of the Dictionary, therefore, improperly calls it a calcareous earth; this name being applicable to such earths only as are convertible into quicklime. 4. It was precipitated from acids by volatile alkali. 5. When uncalcined, it precipitated calcareous earth from acids. When calcined, or otherwise deprived of air, it did not precipitate these earths: hence its attraction to acids is not greater than that of these earths; but the cause of the former precipitation was this, that the sum of the forces which tended to join the calcareous earth with the fixable air of the magnesia, and the magnesia with the acid, was greater than the sum of the forces which tended to join the calcareous earth with the acid, and the magnesia with the fixable air. 6. When uncalcined, or united with air, it precipitated lime from lime-water; which shews, that the calcareous earth had a stronger power to combine with fixable air than magnesia had, since the former earth took this air from the latter earth; by which means the former was rendered mild and unsoluble in water, and therefore was precipitated. This property suggested to Dr. Alston

a method of procuring sweet water at sea, by adding magnesia to water, the putrefaction of which had been prevented by the previous addition of quicklime. 7. By distillation of three ounces of magnesia, five drams of water, containing some small portion of volatile alkali, were obtained.

(o) MAGNESIA, or MANGANESE, is commonly considered as an ore of iron; but the experiments of Mr. Pott and Mr. Cronstedt shew, that this stone contains little or no iron, and therefore the latter author has made a distinct order of this earth, which he calls *terra magnesia*. Its colors are dark-grey, black, red, or white. Its texture is striated, or with concentric fibres, or indeterminate. It has the following properties: 1. It does not effervesce with acids; they, however, dissolve some part of it, especially when it is calcined: spirit of vitriol acquires from it a rose color: aqua regia also acquires color, especially from the black kind. From these solutions fixed alkalis precipitate a white earth. 2. A small quantity of this earth, mixed with glass frit, gives red or purplish colors to the glass. By continuing the fusion, these colors disappear, and also other tinges which the glass may have accidentally received; hence it is used to produce colorless glass. Larger quantities of it are added when a deep purple glass is required. It is also used to give a glazing to pottery. 3. Fused with nitre or with fixed alkali, it gives to warm water various colors, green, purple, red, or blue, which change by agitating the water. 4. Cronstedt affirms, that it desagrates with nitre. Pott says, it does not. 5. Cronstedt says, that he has sometimes extracted a small portion of tin from magnesia. 6. The same author affirms, that the colors given by magnesia to glass are easily destroyed by calxes of arsenic or of tin. Whence does its property

CCCCXXXII. M A G N E T. (p)

CCCCXXXIII. M A L T. The grain is so called which has been made to germinate, and afterwards dried, so as to become fit for the spirituous fermentation, or for making beer. See BEER.

CCCCXXXIV. M A N N A. See SUGAR.

CCCCXXXV. M A R B L E. (q)

CCCCXXXVI. M A R C A S I T E. This name has long been given indifferently to all sorts of minerals, to ores, pyrites, and to semi-metals. Lately it seems to be confined to pyrites; and Mr. Wallerius proposes to apply it only to such pyrites as are regularly formed. This seems to be better than to leave it a vague and indeterminate signification, from the ambiguity and obscurity which might thereby be introduced. See PYRITES.

CCCCXXXVII. M A R L E. (r)

CCCCXXXVIII. M A R S is the name of a planet which chemists have given to iron, and which is still much used in medicine and chemistry. See IRON.

CCCCXXXIX. M A S T I C. (r)

CCCCXL. M A T R A S S. A matras is a bottle with a neck more or less long, used in chemistry for making digestions and macerations. Matrasses are also used as receivers. Their form is different, some of them being spherical, which is the ordinary shape; others flattened at the bottom, called *matrasses with a flat bottom*; and others having the figure of an egg, which last kind are called *philosophical eggs*. These matrasses are chosen according to the operations intended. The most convenient of all, when we do not mean to operate on a large quantity of matter, are bottles of thin glass, known by the name of *medical phials*; because these phials are very cheap, are made of good glass, and may be quickly heated, so that the liquor contained shall boil without danger of being broken. This advantage they owe to their thinness. Such phials are very useful in a laboratory; and therefore a number of them ought always to be kept there. See VESSELS.

of tinging glass proceed? Does it contain any of the known volatile metallic substances, or a new semi-metal?

(p) MAGNET. Magnets are iron-ores, from which a considerable portion of iron may be extracted. Newton says, that they are almost totally soluble in spirit of nitre, and partially in the vitriolic and marine acids.

(q) MARBLES. All those calcareous stones are called, which are hard, which have a crystalline texture, are capable of receiving a polish, and which are considered as precious. For their properties, see EARTHS (calcareous).

(r) MARLE is an earth composed of different proportions of argillaceous and of

calcareous earths. Its properties vary in degree according to the proportions of these earths. Marles effervesce with acids, which property they receive from the calcareous earth. They are fusible by fire, as all mixtures of these two earths are. By a less heat, if the calcareous earth predominates, they are calcinable into a kind of quicklime; and if the clay predominates, they may be changed by fire into hard masses capable of striking ignited sparks from steel.

(s) MASTIC is a resin almost totally soluble in spirit of wine, but not at all in water. It becomes soft and tough, like wax, by being chewed. It is used as an ingredient in varnishes.

CCCCXLI. M A T R I X. (†)

CCCCXLII. M A T T. Ores not perfectly deprived of their sulphur, when fused, are called *matt*. It is obtained in the first fusion for the extraction of metal from some ores. See SMELTING of ORES.

CCCCXLIII. M E N S T R U U M. Menstruum is a word synonymous with solvent. See SOLUTION.

CCCCXLIV. M E R C U R Y. Mercury is the name of a planet, which is also given to the metallic substance called *quick-silver*. But as mercury is the most general name, we shall here relate the principal properties of this metallic substance.

Mercury is a metallic substance of a shining white appearance, entirely similar to that of silver. It is habitually fluid, and consequently we cannot discover either its ductility or the tenacity of its integrant parts.

Its specific gravity is very great: next to gold and platina, it is the heaviest of all metallic substances, and even of all known natural bodies. It loses about  $\frac{1}{13}$  part of its weight in water, and a cubic foot of mercury weighs 947 pounds.

Neither air, water, nor the united action of these two elements, appear to make any sensible impression upon mercury; nor is it more susceptible of rust than the perfect metals. Its surface tarnishes, nevertheless, to a certain degree, and more quickly than gold and silver, when it is exposed to the air: but this is because the dust which floats in the air quickly fixes upon its surface. The watery vapors also which float in the air seem also to be attracted by the mercury.

Mercury may easily be cleansed from those extraneous matters which adhere only slightly to it, by making it pass through a new, clean, and close cloth, and afterwards by heating it. When mercury has been thus purified, and is free from all metallic alloy, it is considerably fluid. A phosphoric light is produced by shaking in the dark such mercury contained in a barometer. Its integrant parts, like those of melted metals, seem mutually to attract each other, and always acquire a convex or spherical form when they touch bodies with which they have no tendency to unite.

Mr. Lemer the younger asserts, that mercury loses no weight by being kept in boiling water; and therefore that water dissolves none of it. Nevertheless, many good physicians are of opinion, that water which has been boiled upon mercury has the property of killing worms and other insects; from which we may suspect, that some mercurial parts are dissolved by the water, although their quantity is too small to be rendered sensible by a balance. These experiments deserve to be repeated with due attention.

Mercury, when exposed to fire, presents many remarkable phenomena. It seems to suffer no change from a heat that is not superior to that of boiling water. With a greater heat it is entirely dissipated in vapors, like other volatile bodies. It undergoes no alteration by having been thus reduced into vapor; for if the evaporation be made in close vessels, that is, if the mercury be

(†) M A T R I X. The matrix of ores is the earthy and stony substances in which these metallic matters are generally enveloped. These are very various, generally spar, quartz, fluors, or horn-blend. See note to the article ORES.

distilled, its vapors when condensed will form the same mercury as before the operation. Mercury remains unchangeable by repeated distillations. Boerhaave distilled 18 ounces of mercury 300 times, without perceiving any other change than that its fluidity and specific gravity were a little encreased, and that some grains of a fixed matter remained: which small changes were probably produced by a purification of the mercury, rather than by any real alteration of it. The vapors of mercury, like those of all other volatile bodies, if they cannot escape, or be condensed, cause violent explosions. Mr. Hellot, of the Academy of Sciences, says, that he was present at an experiment of this kind. A person pretending to fix mercury had enclosed some of it in an iron box closely welded. When the mercury was heated, it burst the iron box, and diffused in invisible vapors.

By digestion in a strong heat, continued during several months, mercury undergoes a more sensible alteration; its surface being gradually changed into a reddish earthy powder, without any metallic lustre, which floats upon the surface of the fluid mercury, without incorporating with it. Thus any quantity of mercury may be entirely converted into a red powder. For this purpose only the proper time and vessels are required. As mercury, thus changed, resembles a metallic precipitate; and as, for this purpose, no addition is necessary; this preparation is called *mercurius precipitatus per se*, or mercury precipitated by itself.

The strongest heat which mercury can sustain is necessary for the preparation of this precipitate *per se*. For Boerhaave, who made long continued experiments upon this substance, with a patience unequalled even by the searchers for the art of making gold, kept mercury in digestion during 15 years, without observing any change, unless that upon its surface a little black powder had formed, which by trituration was easily reducible into fluid mercury. See PRECIPITATE PER SE.

Till lately it was believed that the fluidity of mercury was as essential to it in its natural state as its volatility: so that those even who had labored to render it fixed and solid, expected to attain their purpose only by producing a great change upon its nature. But at present we are assured that by a sufficient degree of cold it may be rendered solid and malleable like the other metals. This truth, which had been conjectured by theoretical chemists, has been lately demonstrated by the Members of the Academy at Peterburgh. These philosophers availed themselves of the intense cold on Dec. 25, 1759, which they further encreased by the artificial methods known, and particularly by the mixture of spirit of nitre with snow, till Mr. de Lisle's thermometer was sunk to the 212th degree. They then perceived that the mercury in the thermometer no longer continued to mark the degrees of cold, and suspected that it had lost its fluidity. Having broken their thermometer, they found that their mercury was actually consolidated. They repeated this experiment upon other thermometers, and found that it succeeded so completely, that after having broken one of these instruments, they extracted the mercury in a solid state, which resembled a small globe of silver, with a flexible silver wire attached to it. They struck this mercurial globe several times with a hammer, and perceived that it was thereby flattened and extended like a ductile metal. Mr. Poissonnier, Physician of the Faculty of Paris, Physician to the King, and Member of the Academy at Peterburgh,

Petersburgh, who then happened to be in Russia, was present, and one of the operators at this important experiment, and was the person who first sent a particular account of it to the Academy of Sciences at Paris (*u*). By this capital experiment it is then well established and authenticated, that mercury is, like other metals, fluid or solid, according to the greater or less quantity of fire with which it is penetrated; that if we only see it in a fluid state, it is because it is so fusible that so small a degree of heat can keep it fluid, that even in the greatest natural colds, a sufficient quantity of heat always remains for that purpose.

This exceeding fusibility of mercury, and its great volatility, together with its great density and gravity, are properties which appear contrary and incompatible, so be found in the same body, and so eminently. In fact, the density, gravity, and solidity of metals, leave no doubt but that the earthy element enters in a great quantity into their composition; and besides, by the calcination of imperfect metals, this element is in some measure developed, and rendered so sensible by essential properties, that it undoubtedly makes part of metals. The extreme density and gravity of mercury seem to prove no less evidently that much of the earthy element enters into the composition of that substance. But on the other side, solidity and fixity seem to be essential properties of the earthy principle. How then shall we conceive, that a substance composed almost entirely of the most fixed and refractory principle, should be exceedingly volatile, and perhaps the most fusible of all bodies? This most undoubtedly proceeds from the presence of some other principle which is eminently volatile and fusible. But what is this principle? Is it phlogiston? or that principle which Becker has mentioned, but not ascertained, and which he calls *mercurial earth*? Is it the union of the inflammable principle and of this mercurial earth? These certainly are objects worthy the curiosity of those who have taste and talents for the sublimest researches in chemistry.

We proceed now to the other properties of mercury, which it discovers when combined with the principal chemical agents.

(*u*) The validity of this experiment, which seems to ascertain the fixation of mercury by cold, has been questioned by counsellor Lehman. According to this author, the mercury employed by professor Braun in the recited experiment had been distilled in the common method through water, and the water only in that experiment was frozen, but not the mercury. He also affirms, that having distilled mercury without water, and having carefully exposed it from all watery particles, he could not congeal the mercury by artificial cold, altho' he at the same time did congeal common mercury. But I think that we must ascribe to the fixability of mercury by cold, as ascertained by the academicians at Petersburgh, and by the disbelievers when they speak concerning the ductility of the mercury thus hardened, which could certainly not be given by the congelation of adhering water. Nevertheless, mercury is said to attract powerfully moisture from the air. The explosions occasioned by exposing mercury suddenly to heat in close vessels are said by some to be produced by water adhering to the mercury. The water commonly contained in distilling mercury which has been exposed to moist air, has induced a belief of the convertibility of mercury into water. Neuman says, that he has observed that the weight of mercury was greater in winter than in summer. Probably this difference proceeded from the mercury having acquired more moisture from the air in the former than in the latter season. See ENCYCLOP. tsm, X. p. 273.

Vitriolic acid in its original state does not act, or but very weakly, upon mercury. These two substances cannot be united together, unless the acid be very highly concentrated, and a very strong heat applied. These two conditions are united in distillation. Vitriolic acid, poured upon mercury and distilled, becomes more and more concentrated; and as it acquires a great heat when it is concentrated, it then acts upon the mercury, dissolves it, and reduces it to a saline, white mass.

In this operation we observe, that the portion of acid which passes in distillation is very much of the volatile sulphureous nature, which might induce us to suspect that the acid seizes part of the inflammable principle of the mercury. Nevertheless, when we afterwards separate the vitriolic acid from the mercury, we find that this metallic substance has received no alteration. This volatile sulphureous quality, therefore, seems more probably to be given to the vitriolic acid by some inflammable matter which the mercury had superabundantly, as most other metallic matters generally have. This deserves a more particular examination.

When the saline-mercurial combination which remains in the retort is mixed with pure water, it divides into two different matters, one of which is perfectly soluble in water, and the other precipitates in form of a white powder, if the water be cold; and of a yellow powder, if the water be hot, and in sufficient quantity. The portion which remains dissolved in the water is a combination of mercury with as much vitriolic acid as is necessary to give it a saline quality. It is a salt with a metallic basis, crystallizable by evaporation of the water. It ought to be called *vitriol of mercury*. The precipitated portion is almost entirely pure mercury, which retains too little acid to give it a saline quality, or solubility in water. It may be totally deprived of its acid, according to Mr. Beaumé, by a sufficient lavation with hot water. This precipitate becomes more and more yellow, when it is washed with hot water; it is a violent emetic, and is known by the name of *turbith mineral*. See that article.

If, instead of treating with water the combination of vitriolic acid and mercury which remains in the retort after distillation, it be cohobated several times with vitriolic acid, Lemery says, that the mercury becomes more and more impregnated with acid, and at last becomes a very corrosive liquor, which some chemists have improperly called *oil of mercury*.

If the combination of vitriolic acid with mercury be exposed to fire, the greatest part of this acid will be expelled; and this remarkable thing happens, that mercury treated thus with vitriolic acid sustains a greater heat, and consequently seems to be somewhat more fixed than when it is pure.

Nitrous acid dissolves mercury very readily; and this solution presents phenomena very similar to those of the solution of silver by the same acid. This acid ought to be very pure; the solution may be made without heat; it is corrosive, and blackens the skin, in the same manner as the solution of silver does. From this solution may be obtained by crystallization a nitrous mercurial salt, which may be called *mercurial nitre*. If this salt be exposed to the action of fire, much of the nitrous acid will be driven from it in the ordinary form of red vapors; and when the acid quits the mercury, the salt, which is at first very white, becomes yellow, then orange-colored, and lastly red. Mercury treated with



with this acid becomes also more fixed. Nevertheless, by a sufficient heat it may be sublimed.

The red powder which remains after the evaporation of the nitrous acid has the appearance of mercury precipitated by itself. It is called *red precipitate*, but improperly, for it is not a precipitate. See *PRECIPITATE*. When spirit of wine has been poured upon it and burnt off, it is called *arcamum corallinum*. See *PRECIPITATE (RED)*.

Marine acid when liquid does not act sensibly upon mercury in its ordinary state, even when assisted with a boiling heat. But when this acid, very concentrated and reduced into vapors, meets mercury also in vapors, these two bodies easily unite together, and even intimately. Hence results a marine salt with basis of mercury, the crystals of which have the form of flattened needles. It is called *corrosive sublimate mercury*, or only *corrosive sublimate*, because it is always made by sublimation, and is at the same time a very violent corrosive.

Corrosive sublimate may be made in several methods. The most common is to take a solution of mercury evaporated to dryness, to mix it with a quantity of calcined martial vitriol and of decrepitated common salt equal to the quantity of mercury dissolved, and to proceed to sublimation by exposing the mixture to fire in a matrafs set in a sand-bath. On one side the acid of vitriol disengages the acid of common salt which rises in vapors. On the other side, the mercury is reduced into vapors by the heat. These two bodies combine together in that state, and form a salt, which being itself volatile, attaches itself in the upper and colder part of the matrafs, where it forms a very white and shining crystallized incrustation, which is the corrosive sublimate. The other methods of making this salt are founded on the same principles. They will be found under the article *COMPOUND SUBLIMATE*.

This salt is of a singular nature, and differs much from all the other combinations of mercury with other acids. Altho' it is extremely caustic, and is capable of receiving still a considerable quantity of mercury, as we shall afterwards observe when we speak of *lunar mercury*, (which qualities indicate an imperfect saturation of the acid) it nevertheless has none of the properties observable in those salts whose acids are imperfectly saturated. It crystallizes well, and very easily; so far is it from being deliquescent, as all these salts are, it is difficultly soluble in water, and requires a large quantity of boiling water to dissolve it entirely. It is consequently a salt which crystallizes by cold. Its crystals are of the same form as those obtained by sublimation, and cross each other irregularly. They resemble a heap of large sword-blades or poignards thrown carelessly together.

If corrosive sublimate be exposed to fire, it will again be sublimed in its original form, without being decomposed, or at least only sensibly. The mercury then, so far from receiving any fixity from the marine acid, as it does from the vitriolic and nitrous acids, seems on the contrary to be rendered more volatile. This phenomenon is analogous to those which are exhibited by other metallic substances with similar acids, the union of which renders all these substances more or less volatile. This acid ought to produce this effect more strongly upon mercury, and it is itself considerably volatile.

This property as well as the others which are peculiar to the combination of marine acid with mercury, are naturally deducible from the presence of

mercurial

mercurial earth existing abundantly in both these substances, if Becker's opinion upon this subject was sufficiently proved. See **SUBLIMATE (CORROSIVE)**.

The affinity of marine acid with mercury is so great, that it overcharges itself in some measure with a considerable quantity of that metallic matter. If corrosive sublimate be triturated in a glass mortar with fluid mercury, it will receive the mercury and acquire a blackish color. By thus adding mercury till it no longer is extinguished (for this kind of combination is called *extinction*) which is known by the globules of mercury not disappearing, we shall find that corrosive sublimate is capable of absorbing or extinguishing about three quarters of its weight of fresh mercury. And if this new mixture be subjected to sublimation, the combination of mercury with corrosive sublimate is completed, and a new sublimate is formed, in which the quantity of mercury is much greater than in corrosive sublimate. When this matter has been sublimed thrice, to render the combination more perfect and intimate, the sublimate is then called *mercurius sublimatus dulcis*, or more frequently *sweet mercury*, because the mercury which is then united to the marine acid forms a compound which is no longer caustic, and which is taken internally as a purgative. See **MERCURY (SWEET)**. It is also called *aquila alba*, the white eagle, and this Latin name is still in use.

Corrosive sublimate is not only rendered less caustic by this addition of mercury, which changes it into sweet mercury, but also the properties of the marine acid, and even its saline qualities are, almost entirely abolished. Sweet mercury has not then, properly speaking, but the external appearance of a saline matter. It is almost entirely undissolved in water, which is the most distinguishing mark of salts.

If sweet mercury be six times sublimed, it loses more and more of its purgative quality, and at last all of it. This change is produced either by a loss of part of the acid each time, or by the combination betwixt the acid and mercury being rendered more intimate. In this state it is called *mercurial panacea*, or merely *panacea*. The panacea taken internally in sufficient doses can then only produce salivation. See **MERCURY (SWEET) and PANACEA**.

The combinations of mercury with the vitriolic, nitrous, and marine acids, may be decomposed by all intermediate substances, which having in general a stronger affinity with acids than metallic substances, decompose all metallic solutions by acids. These intermediate substances are absorbent earths, and alkaline salts, both fixed and volatile.

Lime-water mixed with a solution of corrosive sublimate, precipitates the mercury in form of a red brick-colored powder. This mixture is employed in surgery under the name of *phlegmatic water*. It is used for cleansing ulcers, particularly those which are venereal.

Fixed alkalis precipitate mercury from its solutions in a reddish powder; volatile alkali precipitates corrosive sublimate in a white powder, and the solution of mercury in nitrous acid is a grey flat-colored powder. In general, the colors of the mercurial precipitates are various, and their colors depend, like those of all other metallic precipitates, on the degree of division of parts, and on the quantity of saline matter and of phlogiston retained by their precipitates. See **PRECIPITATE**.

Fixed

Fixed and volatile alkalis do not act, or but insensibly, on mercury, in its proper state; but they can dissolve it, as well as all other metallic matters, when they can be applied to these metallic matters very much divided, as, for example, previously dissolved by acids. Thus when a solution of mercury, with more acid than is necessary to dissolve the mercury, is poured into a very concentrated alkaline liquor, the precipitate formed upon first mixing the liquors will be again dissolved, and will disappear. The volatile alkali may by this management dissolve a very considerable quantity of mercury.

Lastly, vegetable acids which scarcely have any action upon ordinary mercury, are also capable of dissolving it when it is sufficiently divided. Thus if we pour a large quantity of distilled vinegar upon mercury precipitated by a fixed alkali from its solution in nitrous acid, this precipitate will be easily dissolved again by help of a little heat, and from this combination a mercurial salt of a singular nature will be formed.

The acid of vinegar, and probably all other vegetable acids, seem to be capable of contracting a very intimate union with mercury; for the *acetous mercurial salt* which we have just mentioned is not only crystallizable, but is even difficultly soluble in water. Hence, the phlegm of the vinegar not being in sufficient quantity to keep the acetous mercurial salt dissolved without heat, when it is made by the process described, this salt crystallizes in great quantity, when the liquor cools. Its crystals are small, shining, thin plates, floating in the liquor like pieces of silver leaf.

From all the solutions of mercury we have mentioned, we may see, that this metallic matter is capable of being combined with all acid or alkaline saline substances, but with more or less facility and intimacy. Of all the acids, the nitrous dissolves mercury most easily, as it does in general all metallic substances; but it has not the strong affinity with mercury; on the contrary, it seems to be that which contracts with it the least intimate union, as we may see from the following experiments.

If into a solution of mercury made by spirit of niter, vitriolic acid be poured, or the solution of any neutral salt containing this acid, the liquors will be rendered turbid; and when they are hot, a yellow precipitate will be formed, exactly similar to that which is obtained by pouring water upon the combination of vitriolic acid with mercury, that is to say, turbith mineral. This effect cannot happen but because the vitriolic acid is joined to the mercury, which it separates from the nitrous acid.

As this experiment is very manifest, as the turbith mineral is easily known, and as it may be formed from this solution of mercury in the nitrous acid, not only by the vitriolic acid when disengaged, but also by any salts which contain that acid; this solution of mercury, therefore, affords a convenient method of discovering the presence of this acid in many chemical experiments, and particularly in examining mineral waters. Accordingly, it is much used for that purpose; and as, with regard to the vitriolic acid, what the solution of silver in the nitrous acid is to the marine acid, so *WATERS (MINERAL)*.

Marine acid, common salt, and in general all salts which contain this acid, mixed in a similar manner with a solution of mercury in nitrous acid, occasion a precipitate by the action of the marine acid upon the mercury, which it separates from the nitrous acid, and with which it unites, forming a combination,

which appears as a white precipitate, and is accordingly known by the name of the *white precipitate*. We must observe upon this subject, that that precipitate which is only a combination of marine acid with mercury, appears in these experiments as a precipitate, only because it requires more water to keep it dissolved than is to be found in these liquors; otherwise this mercurial salt would remain dissolved, and would not become sensible. In this respect it differs essentially from turbith mineral, which is insoluble in water.

The reason why this mercurial salt is much less soluble in water than the nitrous mercurial salt, is, that the marine acid is more intimately joined than the nitrous acid with the mercury; and also because marine acid has so strong an affinity with mercury, that it overcharges itself with that metallic matter, whenever it meets with a sufficient quantity of it, as in the present experiment. For if we add to the white precipitate, to corrosive sublimate, or to any other combination of marine acid with mercury, a much greater quantity of this acid disengaged, these saline mercurial matters will charge themselves with it superabundantly, and will become so much more soluble in water, as they shall have received a larger quantity of this acid, according to the general rule. See SALTS.

Hence if white precipitate be made by pouring a considerable quantity of disengaged marine acid into a solution of mercury by spirit of nitre, the precipitate ought to be re-dissolved: and it accordingly is so, as Geoffroy, Junker, and Pott, have observed. As in this experiment, mercury is found dissolved in a liquor containing the nitrous and marine acids, some chemists have imagined that mercury was soluble in aqua regia. Nevertheless nothing appears less certain than that conclusion. For it is very possible that mercury may be kept dissolved by a superabundant quantity of marine acid, with which only it is really united, and that the nitrous acid should contribute nothing to this solution. Besides, if the nitrous and marine acids could be both united to the same mercurial parts, why do the white precipitate and corrosive sublimate, both made by help of a large quantity of nitrous acid, contain only the marine acid? The smallest vestige of nitrous acid cannot be discovered in them.

Mr. Pott, in his Dissertation on Common Salt, mentions another fact, which seems to prove not only, that mercury is soluble in aqua regia, but also that nitrous acid may seize upon that metallic matter exclusively of the marine acid. Mr. Pott's experiment consists in pouring spirit of nitre upon corrosive sublimate, by which he observed that spirit of salt was disengaged in vapors.

A modern author draws from this experiment a consequence against the greater affinity of the marine acid than of the nitrous with mercury, supposed by all chemists, and even against the doctrine concerning the tendencies of bodies to one another according to certain laws, called affinities. But, I believe, we may affirm that this experiment is only capable of imposing upon us at first view, and not when we examine circumstances attentively.

If indeed spirit of nitre be poured upon corrosive sublimate, and particularly if the mixture be heated, we may observe the usual phenomena of substances acting upon each other, that vapors are disengaged, not of pure marine acid, but of aqua regia; and if the quantity of nitrous acid be sufficiently large, that the corrosive sublimate will be entirely dissolved in it. But we must observe upon this subject, that as the quantity of mercury is very considerable in cor-

rosive sublimate, we cannot be surprized that nitrous acid, which has great dissolving power upon this metallic matter, and which probably finds it not sufficiently defended by marine acid, should exercise upon it part of its action; but on the other side, as nitrous acid fixes mercury a little, and as the mixture undergoes a certain degree of heat, it is scarcely possible but that a certain quantity of marine acid should disengage itself. But we may easily perceive that this effect is produced by the concurrence of these two circumstances, rather than by a superior affinity of the nitrous acid to the mine, with mercury. For when these two causes cease to act, that is, when the mixture becomes cool, and the action of the nitrous acid is over, the corrosive sublimate is seen to crystallize very quickly even in the nitrous acid, and in as large a quantity as before the experiment.

This is not the only fact which furnishes specious objections against even the most manifest affinities. But in good philosophy, when a single fact is found to contradict many others well established, it ought to be examined very attentively, and in all its circumstances, before the consequences it seems to contain ought to be inferred. We shall now return to our examination of white precipitate.

This combination of marine acid with mercury, being exposed to the action of fire in close vessels, is sublimed into a saline mass, which is considered by Lemery as a sweet mercury, by others as a corrosive sublimate, and, last y, by some chemists as being in an intermediate state betwixt corrosive sublimate and sweet mercury. The last opinion seems to be the most probable; for the sublimate formed by white precipitate is probably not often charged with a sufficient quantity of marine acid to form corrosive sublimate, at least if by that expression we understand mercury sublimed, and united with the greatest possible quantity of marine acid; and on the other side, this sublimate from white precipitate probably contains too little mercury to constitute sweet mercury. But as the marine acid and mercury may be united in very different proportions, according to the state in which they are presented to each other, in this respect very considerable differences ought to be found in white precipitates, according to the methods of preparation. If, for example, mercury be precipitated by a large quantity of disengaged marine acid, this mercurial precipitate will most probably contain a much larger quantity of acid, than a precipitate made by adding common salt to the solution of mercury. If this be true, we need not be surprized that chemists should disagree in their opinions concerning the degree of corrosive quality to be attributed to this sublimate from white precipitate.

We have seen above, that the combinations of mercury with acids may be decomposed, as all metallic solutions may, by earths and by alkalis both fixed and volatile. They may be decomposed also, and particularly corrosive sublimate may, by several metallic substances, such as tin, regulus of antimony, and copper.

Corrosive sublimate, being mixed with tin and subjected to distillation, may be decomposed. The marine acid is applied to the tin, a part of which it carries with it in distillation, and with which it passes in form of an acid, smoking liquor. This acid is called the LIQUOR (SMOKING), or SMOKING SPIRIT of LIBAVIUS; which see.

Antimony or its regulus, being mixed and distilled with corrosive sublimate, also decompose it; the regulus taking the marine acid from the mercury, and passing with that acid in form of a thick liquor, which congeals by cold, and is known by the name of *BUTTER of ANTIMONY*. See *that article*.

If very clean plates of copper be steeped in a solution of corrosive sublimate, the acid of that salt will attack the copper, and the mercury will be deposited upon the surface of the copper, with its metallic lustre, which always happens when one metal is precipitated by another. See *PRECIPITATION and PRECIPITATE*.

As mercury revived is always fluid, and therefore capable of being allayed with any metallic matter which it can touch, it amalgamates in the present experiment with the surface of the copper, and forms there a beautiful, white, and shining silvering, capable of surprizing persons ignorant of these effects, and of making them believe that copper is thus changed into silver. But to make this experiment succeed well, we must add some marine acid, or some sal ammoniac to the solution of corrosive sublimate. This experiment succeeds equally well with the solution of mercury in spirit of nitre, but always better when the acid is larger in quantity than is sufficient to dissolve the mercury. The surface of the copper immersed in these liquors becomes instantly silvered, and then it must be immediately withdrawn, washed in clean water, and wiped by rubbing it with a dry cloth.

When corrosive sublimate and the other combinations of mercury with acids are decomposed by proper intermediate substances, the mercury is always by that operation *revived*, that is, reduced to a fluid state, and is obtained in that state when the operation is made by distillation, by giving a heat sufficient to raise it. But when the intermediate substance is a compound body, such as antimony, which contains a principle capable of uniting and subliming with mercury; then the mercury which is disengaged from the corrosive sublimate, instead of being revived, makes part of a new combination, and is sublimed in form of cinnabar, if antimony was used, from the union it contracts with the sulphur of the antimony. See *BUTTER of ANTIMONY, and CINNABAR*.

Sulphur acts strongly on mercury. If these two substances be triturated together, the mercury will be easily divided; its molecules will be distributed betwixt those of the sulphur, and will adhere to it; the mixture will acquire a color more and more brown, or blackish, which is a certain sign of the division of the mercury; in a word, the mercury disappears entirely, because it is extinguished and incorporated with the sulphur. When the sulphur has thus absorbed all the mercury which it can receive in this method, the mixture is called *ethiops mineral*, from its black color.

The same combination may be made by fusion, that is, by mixing the proper quantity of mercury with melted sulphur. These two substances unite together, as when triturated, and form a black compound, called *ethiops made by fire*. By this method the union of the sulphur and of the mercury is made much more quickly, and somewhat more intimately. See *ETHIOPS MINERAL*.

When mercury and sulphur have been united together only by fusion or trituration, the union is not sufficiently strong, nor the proportions suitable for making the most perfect and most intimate combination, called *cinnabar*; for

for the preparation of which, sublimation is necessary. By sublimation of the ethiops, the mercury and sulphur are raised together, and are more intimately combined. But we must observe, that in this sublimation a part of the sulphur of the ethiops, which is superabundant to the combination of cinnabar, is separated; so that only one part of sulphur remains united in the cinnabar with six parts of mercury. This superabundant sulphur is not entirely separated by one sublimation. The sublimation must then be repeated several times, that the cinnabar may be entirely free from the superabundant sulphur. The sublimate, which is at first black like ethiops, becomes more and more red, as the mercury and sulphur approximate more and more to their proper proportions; and lastly, it remains in form of a very weighty, deep-red, striated mass, when the cinnabar is perfect. The red color of the cinnabar is so deep, because the matter is exceedingly dense; for when it is finely powdered, it acquires a fiery red color, and is then called *vermillion*, which is used in painting.

This combination of mercury with sulphur is found native, and is called *native cinnabar*, to distinguish it from that made by art. Native cinnabar is mercury mineralised, or the ore of mercury. See ORES.

The connexion of mercury and sulphur is so strong in cinnabar, that the principles of this compound are not disunited merely by the action of the fire, without burning the sulphur. Thus cinnabar exposed to fire in close vessels does only sublime, without any decomposition or alteration. To decompose, therefore, cinnabar, and to separate the mercury from it, some intermediate substance must be employed, which has greater affinity than mercury with sulphur. These intermediate substances are calcareous earths, fixed alkalis, iron, copper, lead, silver, and regulus of antimony. If, then, cinnabar be mixed with any of these substances, and be distilled, the mercury will disengage itself and pass into the receiver, where it will appear in its proper fluid form; and the sulphur will remain in the retort combined with the intermediate substance.

The mercury obtained in these operations is said to be *revived from cinnabar*. It is justly considered as the purest, and fittest for chemical and medicinal purposes, and even for the arts in some cases where very pure mercury is required.

The mercury obtained by the decomposition of cinnabar is not only very pure, but the whole quantity which was in the cinnabar is thus obtained, when none of it is lost in the operation; which proves that mercury suffers no alteration from the sulphur. See CINNABAR.

Mercury, which, from what we have said at the beginning of this article, is to be considered as a melted metal, also acts as such with regard to all earthy and metallic matters. Like other melted metals, it cannot contract any union with earthy substances, not even with metallic earths; but it may be very well alloyed with almost all metallic matters in the following order: Gold, silver, lead, tin, copper, zinc, regulus of antimony. Iron is not numbered amongst the metals capable of uniting with mercury, because no method has yet been discovered by which they can be united together.

The alloys of mercury with metals are called *amalgams*, and are employed for many important purposes. The amalgams of gold and silver are employed



for gilding and silvering, and for the extraction of these two metals from their ores; that of silver is employed for preparing the *arbor Diane*; that of tin for silvering looking-glasses, for mercurial balls, and for the preparation of the smoking spirit of Libavius. See all these words, and the articles ALLAY and AMALGAM.

All fat and oily matters, vegetable or animal, act upon mercury. If mercury be triturated with any grease, it suffers an alteration similar to that in the preparation of ethiops by trituration. The parts of the mercury are thereby very much divided, and made to unite with those of the grease. The mercury disappears, is perfectly extinguished, and acquires a black and leaden color. This combination of mercury and fat is called *mercurial ointment*, and is very useful in medicine; as we shall afterwards see.

The mercury in mercurial ointment must not be considered merely as distributed and intermixed with the parts of the fat: on the contrary, there is an adhesion and even intimate combination between the integrant parts of these two substances; for this fat very quickly becomes rancid, as all oily matters do when combined; and besides, when mercurial ointment has been made a considerable time, all the mercury cannot be separated from it even by fusion. This fact has been verified by Mr. Beaumé.

Mercury, exposed to the vapor of melted lead, or thrown into boiling linseed oil, loses its fluidity, and becomes so solid, that it may be formed into toys and small utensils. Although, properly speaking, this is only an apparent fixation of mercury, since all its fluidity is restored to it by a little heat; this experiment proves, nevertheless, that some principle in these substances, probably their phlogiston, is capable of acting sensibly upon mercury.

Persons engaged in the discovery of the art of making gold, or of meliorating metals, considering that mercury has the metallic lustre, and a gravity approaching to that of gold, have endeavored much to fix it; that is, to deprive it of its volatility and fluidity, intending always to give it the color of gold afterwards by a philosophical tincture. The false fixations of mercury above-mentioned seem to indicate, that if any method by which mercury could be fixed were discovered, which is not very probable, this method must consist in giving it some principle that it wants. Nevertheless, all the properties of mercury seem to shew, on the other side, that its fusibility and volatility depend on some metallic principle united with it superabundantly; and, consequently, that its fixation ought rather to be effected by depriving it of some principle, than by any addition. However, we are certain that it must be effected by the one or the other, or by both these causes united. (\*)

(\*) The purification of mercury from extraneous substances is important for the purposes of medicine and of the arts, and especially for some nice chemical operations. Mercury may be cleansed from dust, by straining it through shamoy leather; from grease, by washing it with an alkaline lixivium; from any alkaline matter, by vinegar; from lead, or bismuth, with which it is frequently adulterated, by distillation; from

sulphur, by mixing it with quicklime or with filings of iron, and then distilling the mixture. The best method of purifying mercury is by reducing it into ethiops mineral, with which twice the quantity of quicklime or of filings of iron is to be mixed; and by distilling it from this mixture. Its purity may be known, by observing that it does not soil clean white paper; that it has no pellicle on its surface; that when triturated with



Mercury is one of the metals which best deserves to be well known, not only from its great importance to chemistry and to the arts, but also from the powerful remedies it furnishes against diseases incurable by other means, particularly those called venereal diseases. The medicinal use of mercury has been known only since the introduction of those diseases into Europe. The ancient physicians did not use it, but considered it as a poison. This opinion seems to have been founded upon some accidents from mercury ill prepared, or given improperly, or perhaps from the tremblings and diseases to which artists who handle mercury much are subject. However that may be, the Arabian physicians were the first who ventured to use mercury medicinally, and they employed it successfully against the itch, and other diseases of the skin.

When the venereal disease first appeared in Europe, in the army of Charles VIII. at the siege of Naples, a physician, called Beranger de Carpi, considering that the new disease discovered itself by cutaneous pustules, similar to those of malignant itches, and encouraged by the example of the Arabians, attempted the cure by mercury, and succeeded. Nearly about this time, chemists and alchemists directed much of their labors towards medicine, and discovered many chemical remedies, the best of which are preserved, and employed at this time with success. The famous Paracelsus chiefly distinguished himself in this way,

with water, it does not soil the water; that when exposed to fire in an iron spoon or laddle, it does not crackle; and, lastly, that it is perfectly and entirely soluble in pure spirit of nitre, without any deposition.

*Mercury may be united with all metallic substances, excepting iron, arsenic, and the semi-metal called nickel. See a note under the article IRON.* Dr. Lewis observes, that in some cases mercury absorbs gold and silver from their solutions in acid and in alkaline liquors. This it may do by precipitating these metals, from its greater affinity to those menstrua, and by uniting or amalgamating with the very minute particles thus precipitated.

The mercury of an amalgam exposed to heat, raises along with it some of the amalgamated metal, even of gold, as happens in the gilding of metals by amalgamation. Mere distillation, therefore, may not be sufficient to procure mercury perfectly pure from metals. By the above-mentioned method of mixing it with sulphur so as to form an ethiops, and afterwards with quicklime, and by distilling the mercury from that mixture, it may be obtained well purified from metals, which will remain engaged in the sulphur, or rather liver of sulphur, formed by the sulphur and quicklime. By no method can purer and brighter mercury be obtained than by distilling it from cinnabar, by intervention of filings of pure iron. In

all distillations of mercury, the addition of filings of iron seems to render the mercury more fluid and bright; probably by giving phlogiston.

The volatility of mercury may be diminished by several methods; some of which we shall mention. 1. Mercury calcined by heat, called the precipitate *per se*, sustains during some time a red heat, and by exposure to the heat of a burning glass is vitrifiable. 2. Dr. Brandt relates a very curious experiment, from which mercury appears capable of being so detained and fixed by digestion with gold, that a considerable part of it cannot be separated from this metal by the most intense heat. 3. Mercury may be rendered considerably less volatile by being combined with vitriolic acid, but especially with the vitriol of silver, or the salt formed by silver and vitriolic acid. This salt may be united with a considerable portion of mercury, with which it forms a concrete substance fusible by fire, but capable of sustaining, according to Dr. Lewis, the greatest heat that can be applied to glass vessels, without dissipation of the mercury. 4. Neuman says, that if mercury sublimate be frequently sublimed with sal ammoniac, and each time the sublimed matter mixed with the residuum, the whole becomes at last so fixed in the fire, that it cannot be any more sublimed.

and treated venereal diseases with astonishing success, by internal remedies, in form of pills. Although he has not published his remedies, it is believed from their effect, that the basis of them was *turbith mineral*. Since that time mercury has been used in a great variety of forms.

Crude and fluid mercury taken internally produces no effect in the body; because the adhesion of its integrant parts to each other hinders their division, and distribution, or solution, without which it cannot have any effect. In its crude state, therefore, it does nothing but load the stomach and intestines. It falls downwards by its weight, and goes out of the body along with the feces in the same state in which it entered.

Several physicians have believed that mercury, swallowed in its crude state, may be useful in the iliac passion, imagining, that by its weight it is capable of reducing the intestines to their proper situation. But the effects are not suitable to their expectations. We have even seen this disease rendered worse by mercury, from the shooting pains it occasioned in these parts, already pained and irritated by spasms. The use of crude mercury is now abolished in these diseases.

But when mercury is much divided, so that its molecules cannot again unite and form fluid mercury, in whatever manner this division may have been made, it then produces very striking effects, and such as may be expected from the most powerful remedies.

Mercury administered in this state accelerates the pulse, divides and carries off the thickened humors, augments in general all excretions and secretions, but some preferably to others, according to circumstances. If it be in a saline state, or capable of being easily put into one, and be thus introduced into the body by the stomach in sufficient quantity, it acts as an evacuant, purgative, or emetic. Mercurial frictions and fumigations chiefly encrease the secretion of saliva, and this in proportion to the quantity and number of doses. Mercury, in every form, if sufficiently divided, cures diseases; and every preparation has its peculiar advantages and disadvantages, which render it more or less adapted to particular circumstances. We shall here mention the effects of the ordinary preparations of mercury.

Mercury precipitated *per se*, being much divided, is capable of entering the blood-vessels; and when given in doses from two to six grains, properly repeated, produces salutary effects in venereal diseases. Notwithstanding that it contains no saline matter, it is frequently purgative and even emetic, and is then less disposed to salivate. But we must observe, that this preparation is a mercury exceedingly divided; that every body in this state, and mercury perhaps more than any other, is disposed to be attacked by every solvent; that it meets in the *primæ viæ* several substances, even of the saline kind, which are capable of dissolving it; and that then it must produce the effects of a saline mercurial combination, which effects are in general purgative or emetic. These properties of the precipitate *per se* shew, that it may be successfully employed in many cases. Nevertheless, this preparation is not much used, perhaps because it is very dear.

The combination of mercury with a sufficient quantity of vitriolic acid, to render it soluble in water, is very corrosive, and therefore not given internally.

Turbith mineral taken internally produces nearly the same effects, and in the same doses as the precipitate *per se*, and undoubtedly for the same reason; for  
if

if it retains a little vitriolic acid, as most chemists have believed, this small quantity of acid seems to be sufficient to make it act as a saline mercurial combination: and if, on the contrary, when it is perfectly washed, no acid remains, it will be entirely similar to the precipitate *per se*, and, like this precipitate, will be disposed to receive a saline state, and to act in the same manner. Turbith mineral has been much commended, and is still used by some persons in venereal diseases.

All the precipitates of mercury, when separated from any acid by an alkali, and afterwardsedulcorated, ought to produce internally the same effects as the precipitate *per se*, and as turbith mineral, supposing it to be freed from all acid by lotions. Thus the great number of such mercurial preparations nearly equivalent to each other, are but little used, which must be attributed to the want of attention to their nature and advantages.

The solution of mercury in the nitrous acid, and mercurial nitre, are justly ranked amongst corrosives.

Some persons, and Lemery amongst others, say, that they may be taken internally if they are diluted; an ounce of solution, for example, with 24 ounces of water or ptisan. This is called *mercurial water*.

Lemery says, that from half an ounce to an ounce of this mercurial water may be taken in a glass of ptisan, or broth, and that it vomits gently, and excites salivation. Mr. Baron, in his notes on Lemery, justly exclaims against the use of that dangerous remedy. Nevertheless physicians of great reputation have introduced, and even successfully, the use of corrosive sublimate for the cure of venereal diseases, although this preparation is no less corrosive than the solution of mercury in nitrous acid.

A pomatum is made of two ounces of mercury dissolved in a sufficient quantity of nitrous acid, and mixed perfectly well in a mortar with two pounds of hog's-lard. This pomatum admirably cures the itch. The solution of mercury acts powerfully upon the hogs lard with which it combines, and to which it gives greater solidity, while at the same time it is itself rendered thereby much milder. The pomatum is of a citron color, and is to be lightly rubbed upon the parts attacked by the itch, which by this treatment soon disappears. This pomatum for the itch comes from the Hotel-Dieu at Paris, where it is given to convalescents, by which they are quickly cured of the itch, which they all catch by remaining some time in the hospital. The receipt of this pomatum is also found in the last edition of the Dispensatory at Paris.

Red precipitate is not used internally, but is employed externally as a detergent and cicatrising escharotic, in the treatment of venereal ulcers.

All the combinations of mercury with marine acid are used. Of these the corrosive sublimate has been the least used, in France at least. The terrible accidents and deaths occasioned by small doses of this preparation have confined its use to external application, as an escharotic; and even then it is generally rendered milder, or rather decomposed by mixture with quicklime. But some years ago Van Swieten, a disciple of Boerhaave, and principal physician to the Empress-Queen, introduced the internal use of corrosive sublimate for the venereal disease. This great physician dissolved twelve grains of sublimate in two pounds of malt spirits, and gave this solution by spoonfuls, diluted copiously with emollient liquors.

A great

A great number of trials made by Van Swieten and many others of the profession have proved, beyond any possibility of doubt, that corrosive sublimate, administered in this manner, is a powerful anti-venereal, capable of curing inveterate poxes, which have resisted the other ordinary preparations of mercury. We know besides, that the internal use of corrosive sublimate has been long established amongst the Tartars and amongst the Russians, whose unrestrained manner of living with all sorts of women exposes them to a continual accumulation of venereal diseases.

But notwithstanding these powerful motives to confide in this remedy, many excellent physicians are still deterred from the use of it. They observe, that the use of corrosive sublimate seems only to agree with cold climates, and they believe that it always has disagreeable consequences in such as are hot or temperate. They think that a number of compleat cures, without any seeming inconveniencies, do not justify the use of a substance which is so corrosive, that very bad consequences may be apprehended from it, when it has been once introduced into the body.

Opinions therefore are still divided upon the internal use of corrosive sublimate. Time and experience must decide concerning them. But this is certain, that a remedy of this kind cannot be administered with too much caution, prudence, and discernment; that every one ought not to pretend to meddle with it; and that this, and most other very active substances are kinds of poisons, and only become powerful remedies in the hands of able physicians.

If it were once established, that corrosive sublimate given internally cures venereal diseases radically, and without troublesome consequences, we should think it certain, that the saline combinations of mercury with the other acids may be employed as safely for the same purposes; that is, the vitriolic and nitrous mercurial salts; for these salts are not more, perhaps less, caustic than corrosive sublimate: and besides, the vitriolic and nitrous acids being more disposed to unite with oily matters than the marine acid, they are therefore more susceptible of being rendered milder within the body than the corrosive sublimate, which ought therefore to be considered as the most dangerous of all that are used in medicine.

*Sweet mercury*, not being corrosive, may certainly be used internally, and has been so a long time. But notwithstanding the great quantity of mercury with which the marine acid in this compound is charged, it still retains sensibly a saline quality, and is purgative, when taken from four grains to 15 or 18. It is used in the treatment of venereal diseases, particularly when it is intended to purge. But it is not usual to attempt the cure of a true pox by this remedy only. The *mercurial panacea*, which is only apparently saline, acts, when taken internally, simply as mercury deprived of its fluidity, but too little divided to acquire a saline quality in the alimentary canal: accordingly it does not generally purge, but rather salivate, when given in a large enough quantity. The dose of it is from ten grains to twenty-four or thirty. It is to be repeated as occasion requires, and at proper intervals. Several persons of the profession cure the pox by this remedy only.

*White precipitate*, however it be made, is much more saline than sweet mercury. Accordingly it excites vomiting, and must be given more cautiously and in less quantity; but it is little used. Nevertheless, if the propriety of using corrosive sublimate were established, this precipitate may also be advantageously

advantageously employed with proper management. It would probably produce the same effects in a larger dose.

No sensible effect is produced by the combinations of mercury with sulphur, whether *ethiops* or *cinnabar*, taken internally, and in large doses. Some physicians therefore reject these mercurial preparations as useless and inactive. This is certain, that mercury united with sulphur has no saline quality, and is very little acted upon by menstrua, because it is defended by the sulphur, nearly as the regulus of antimony is in antimony. Cinnabar is used nevertheless in venereal diseases, and successfully on certain occasions, and then it is decomposed by burning. The body of the patient is exposed to the vapors of mercury, which are disengaged by this burning. These mercurial vapors insinuate themselves through the pores of the skin, excite salivation, and cure the venereal disease. This is called *the method by fumigation*.

We know yet very little the effects which are produced by combinations of mercury with vegetable acids, if it be true that Keyser's pills have for their basis the acetous mercurial salt, as is very probable. We may nevertheless suppose that mercury administered in this form might produce good effects.

Lastly, of all the preparations of mercury, the most generally employed is certainly that called *mercurial ointment*. It is, as we mentioned above, mercury extinguished by citruration with fat. The only method of using this ointment is by rubbing it on the body of the patient, and repeating this friction at proper intervals and in proper doses, till a sufficient quantity of mercury has been introduced to effect a cure. This is called *the method of friction*.

This method is more prevalent than the others. It is recommended by the best physicians, and particularly by the learned Astruc. The chief motives for this preference are, that mercury introduced by this method has no corrosive quality, and that as much of it as is necessary for the cure may be thus introduced without inconvenience.

Mercury administered by friction or by fumigation produces no purgative or emetic effect, because it does not enter into the body by digestion, but is immediately introduced into the lymphatic and blood vessels. There it circulates, and penetrates into their most remote recesses. When sufficient doses of it are given, it produces almost always a salivation more or less strong, makes the symptoms disappear, and subdues at length the venereal poison.

This is all that we know concerning the effects produced by mercury. The nature of this poison, and the precise manner of the action of the mercury, are still unknown. Many physicians believe, that, as mercury is capable of a division into very minute but weighty globules, these globules act mechanically by their number and by their weight upon the lymph, which they supposed to be thickened and coagulated by the venereal poison, and which by this action of the mercury was attenuated, divided, and restored to its ordinary state. But this opinion, although one of the most specious that has appeared upon the subject, is nevertheless far from the truth; for if this opinion were just, mercury could only, while it was fluid and in its proper state, cure the venereal disease. But experience has proved incontestably, that mercury in a saline state, such as it is in corrosive sublimate, and consequently deprived of all the properties of ordinary mercury, cures the pox effectually, and particularly in a dose infinitely less than when it is administered by friction or fumigation.

Hitherto it seems to have been believed, that mercury in the mercurial ointment is only divided, dispersed, and interposed betwixt the parts of the fat, without being truly dissolved and combined; and this undoubtedly has given cause to the above-mentioned opinion. We are nevertheless certain, that much of the mercury contained in the ointment is really combined either with the acid, or with the whole substance of the fat. This being established, may we not conclude, that mercury cannot cure the venereal disease but when it is really dissolved, and deprived of its properties of fluid mercury; that only the portion of mercury in the ointment, which is thus combined, affects the cure, and that the other portion of the mercury which remains in its natural state in the ointment (for much of the mercury is in this state) passes into the body without producing any effect; for which reason the mercurial salts cure in much less doses than the mercurial ointment; that, lastly, if the portion of mercury introduced into the body in its proper state by friction or fumigation contributes to the cure, the reason of it is, that the most divided part of this mercury unites within the body with some greasy or other substance with which it is capable of combining?

If this be true, ought we not to search for some new combination of mercury, which shall be at the same time very soluble and free from causticity? Such a remedy would certainly be very precious. For although the mercury of the mercurial ointment is not caustic, and although the method by friction is undoubtedly the most advantageous and certain, it is not however free from inconveniencies. It frequently exposes to dangerous salivations, accompanied with very troublesome accidents; and if to avoid them, the quantity of ointment be diminished, and the intervals of the several frictions lengthened, by which indeed these accidents are avoided, the cure then is not only of a tedious length, but is also sometimes imperfect, or less certain.

But have we reason to flatter ourselves with the hopes of finding such a preparation of mercury? If we consider that mercury has been tried in a great variety of methods, and by very able chemists, and that, notwithstanding, no preparation has yet been found free from inconveniencies, we shall be apt to despair of success in this inquiry. But on the other side, if we reflect on the nature and properties of mercury; if we consider that this singular substance, as we have seen in the present article, is perhaps one of those which may be combined in the greatest variety of manners; that it is acted upon by almost every solvent; we may still have hopes of finding a mercurial preparation, not only much superior to those hitherto known, but which perhaps shall be attended with no inconvenience.

The use of mercury is not confined to the venereal disease. We have already seen, that its antiveneal quality was discovered from its property of curing the itch, even the most malignant; and, in fact, it does cure much more readily and efficaciously than any other remedy, not only the several kinds of the itch, but also many other cutaneous diseases more or less similar to the itch, and which are very various.

Another medicinal quality of mercury is, that of destroying the worms and insects of all kinds which are apt to infest the human body, either internally or externally. In the cure of these two latter kinds of diseases, the same preparations of mercury, but smaller quantities, are employed as for the venereal disease.

Lastly,

Lastly, some observations made lately by able physicians seem to give hopes, that by mercury another scourge more terrible, but fortunately less frequent, than those diseases above-mentioned, namely, the madness occasioned by the bite of a mad dog, may be cured. But this effect of mercury is not sufficiently established, and requires to be confirmed by many new observations, which would require a considerable time, since happily the occasions of trying them are not very frequent.

Physicians, struck with the surprizing success of mercury in certain very obstinate and otherwise incurable diseases, were induced to try it in most of the other diseases which were incurable by the ordinary remedies; and particularly in those which were attributed, as well as the venereal disease, to a thickness or coagulation of lymph, such as the scrophula, cancers, schirrus, and others of this kind. But mercury was not found to have any good effect in these diseases; and some diseases, such as the scurvy, the symptoms of which are so like those of the pox that they cannot easily be distinguished, were not only not diminished, but aggravated by mercury.

We may still however hope, that so powerful a remedy may be employed successfully in other diseases. Perhaps for this purpose only some new method of preparing it is wanting. But even at present, it is one of our most valuable remedies.

CCCCXLV. MERCURY (ANIMATED). This is mercury purified by alchemical processes, for the preparation of the philosopher's stone.

CCCCXLVI. MERCURY (SWEET). Sweet mercury, called also *aquila alba*, is corrosive sublimate combined by further operations with all the mercury which it can receive, and afterwards sublimed thrice.

To make sweet mercury, corrosive sublimate is to be triturated carefully in a glass mortar with fluid mercury, which is to be added gradually as it disappears. This is to be continued till the corrosive sublimate is saturated and will receive no more mercury, which is known by the globules not disappearing by trituration. Lemery says, that corrosive sublimate can only receive about three quarters of its weight of fresh mercury; nevertheless a larger quantity, a half, may without inconvenience be added, because thereby the corrosive sublimate will be more perfectlyedulcorated, and the superabundant mercury will be easily disengaged; as we shall soon see.

The corrosive sublimate receives from the mercury with which it is triturated a blackish-grey color, which color mercury always acquires when it is much divided, and still retains its metallic state. This grey matter is to be put into one or more matrasses with short necks, or rather into the vessels called medical phials, so that two-thirds of the containing vessel shall be empty for the sake of the sublimation.

These matrasses are to be placed in a sand-bath, and sunk in sand to the height of the contained matter. The fire is then to be gradually augmented till we see that the sublimation begins. It is then to be kept in this state till it be all sublimed, and attached to the top of the vessel, excepting a small portion of fixed matter which remains at the bottom. When the matrasses are cold, they are to be carefully broken. The white compact sublimate is to be separated from some less white and dense adhering to the neck of the vessel, to be again powdered, and sublimed a second and a third time in the same manner, always taking care to separate each time the compact white mass from that part which

has less of these qualities. The sweet mercury is then in its most perfect state; a white, heavy, semitransparent mass, smooth as glass in its convex part, where it adhered to the vessel.

In these operations no mortars must be employed, upon which the acid or the mercury of the corrosive sublimate can act: therefore neither marble nor metal mortars are proper, but those made of glass.

Although the crude mercury which is triturated with the corrosive sublimate is joined to it superabundantly, and contracts with it a certain degree of union, this union is not nearly so intimate as it may be, and as it is after the perfect dulcification of the corrosive sublimate; for if we take internally corrosive sublimate impregnated by trituration alone, with all the crude mercury which it can perfectly extinguish, it would produce nevertheless very violent corrosive effects. By sublimation then the new mercury is completely combined with the acid of corrosive sublimate, which is thus rendered milder. The external mark of this intimate combination is the change of color from an opaque grey, which the matter had before sublimation, to a transparent white, which it afterwards acquires. This opaque grey color proceeds, as we said, from the mercury preserving its metallic state, which it does because it is not intimately enough combined with the acid; and the white, transparent, saline appearance is a certain sign of this intimate combination.

One or two sublimations are not sufficient to change entirely the corrosive sublimate into sweet mercury; experience shews that three sublimations are necessary. The mercurial sublimate may then be taken internally without danger. It is no longer corrosive, nor retains any more of its saline property than is sufficient to render it purgative in a dose from four or five to twenty-four or thirty grains: and if sweet mercury be sublimed eight or nine times, or perhaps less, it loses its purgative quality, and is then called *MERCURIAL PANACEA*. See *PANACEA*.

The matter which adheres to the neck of the retort, particularly in the first sublimations, is an imperfect combination of crude mercury with corrosive sublimate, and must therefore be separated from the rest of the mass. When the quantity of crude mercury triturated with corrosive sublimate is more than can be united with it into sweet mercury, the superabundant mercury remains in its metallic state, and gives a grey or blackish color to the sweet mercury. This superabundant mercury may be disengaged by subliming in a retort, as Stahl proposes, and as Mr. Baron remarks in his *Notes on Lemery*.

The fixed matter which remains at the bottom of the matrass is quite extraneous to the mercurial sublimate. It is a portion of earthy substances proceeding from the salts employed in the preparation of corrosive sublimate, and which this sublimate had carried along with it in sublimation. For, in general, volatile bodies are capable of carrying along with them a part of the fixed bodies with which they happen to be mixed, particularly when they are exposed to a stronger heat than is necessary for their sublimation. For this purpose no union betwixt the fixed and the volatile bodies is necessary. This is done by a purely mechanical impulsion of the volatile parts against the parts of the fixed body. Hence the heaviest volatile bodies must produce this effect more sensibly than those which are lighter. Accordingly, the sublimate of mercury, which are certainly the heaviest of all volatile bodies, produce this effect surprizingly. For in the operation for sweet mercury, sometimes fragments

of



of the matrasses in which the sublimation had been made, and which adhere to the matter which is again to be sublimed, are raised along with the mercurial sublimate. Mr. Beaumé has frequently found large fragments of glass in the middle of masses of the sublimate, which had been made in great works, where the same care and attention are not given as in the small operations of chemical laboratories.

Lemery remarks, that sweet mercury acquires a yellowish color when it is triturated. This color proceeds from the quantity of mercury being considerable with respect to the acid; for that is the ordinary color of mercury when it is much divided, and has not its metallic lustre, as we see from the example of the precipitate *per se*, of turbith mineral, and other preparations of mercury which are in this state. See MERCURY, and SUBLIMATE (CORROSIVE).

CCCCXLVII. MERCURY of PHILOSOPHERS. Alchemists have given the name of mercury to many other things besides the metallic substance generally so called. This latter they call ordinary mercury, and value it little. We cannot precisely say what they meant by their mercury, from the obscurity of their writings, and also from their different descriptions of the matter. No term is more frequently used by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the same idea annexed to the term *philosophical mercury*. The most probable opinion upon this subject is, that this mercury is the metallic principle which Beccher has called *mercurial earth*. See EARTH (MERCURIAL), and the following article.

CCCCXLVIII. MERCURIFICATION. Mercurification is an alchemical operation, by which metals are said to be reduced into a fluid, heavy, opaque, and shining liquor, like ordinary mercury; or by which the mercurial principle may be extracted from metals, and obtained in the form of quicksilver. But, these mercurified metals, or their mercurial principle rendered sensible, are a kind of philosophical mercury, which, although they resemble ordinary mercury, are nevertheless said, by persons exercised in such studies, to differ from it considerably, by having a greater specific gravity, by more effectually penetrating and dissolving metals, by a stronger adhesion to these, and by a less volatility.

We may find in the books of many authors, who, though not alchemists, give more or less attention to these subjects, a great number of processes for mercurification, or for obtaining the mercury of metals; most of which are very long, laborious, confused, and consequently subject to fail. The detail of these processes would be too long. An account of the principal of these operations may be seen in *Junker's Conspectus Chemicæ*. We shall only mention some of the easiest mercurifications, extracted from the most modern authors, as *Wallius* and *Teichmeyer*.

If cinnabar of antimony made with corrosive sublimate be distilled, we shall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corrosive sublimate.

If a corrosive sublimate be prepared with spirit of salt and fluid mercury, and if calx or filings of silver be several times sublimed together with this corrosive sublimate, a part of the silver will be changed into mercury.

Very fine filings of iron, exposed during a year to the air, and afterwards well triturated in a mortar, and cleansed from dust and extraneous matter, then

exposed during another year to the air, and, lastly, distilled in a retort, furnishes a hard matter which attaches itself to the neck of the retort, and with this matter a little mercury. *Teichmeyer.*

If calx of copper be mixed with sal ammoniac, and this mixture exposed during a certain time to air, and distilled with soap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated spirit of salt, digested together during three or four weeks, then an equal quantity of black flux and Venice soap added to it, and the whole matter distilled in a glass retort, some mercury will pass into the receiver.

These experiments are important and easily made, but have not been repeated by modern chemists; for which we see no other reason than the small hopes of their succeeding. If they should succeed, they would ascertain the existence of a mercurial principle in metals, and would so much more confirm the theory of Beccher, as all the experiments above-mentioned are made with the marine acid, which that chemist supposes to contain the mercurial earth. The conclusion deducible from these experiments would be, that, by introducing a superabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. *See METALS.*

Many other processes for mercurification may be seen in authors who have treated of this matter, particularly in Junker's book above quoted, in which marine acid is not employed, but other saline matters, or sublimation through the burning fuel, with concurrence of free air, in Gebér's manner. In this latter case, we must look for the mercurial substance in the metallic fumes and flowers; and if any such substance be obtained, it must evidently proceed from the decomposition of the metallic matter employed.

Mr. Grosse lays, in the Memoirs of the Academy, that he obtained mercury from lead by an easier and simpler process than those above-mentioned. This consists in saturating perfectly some good nitrous acid with lead, which may be done effectually by employing more lead than the acid can dissolve; and from this solution, according to Mr. Grosse, a grey powder is precipitated, in which mercury is discovered. This experiment being short, Messrs. Macquer and Beaumé repeated it with due attention in their Course of Chemistry; but they did not find the grey mercurial powder mentioned by Mr. Grosse. As the exactness and veracity of that able chemist are well known, we must believe that the lead which he employed contained some extraneous mercury, which might easily happen in a laboratory. The same thing has possibly happened in other experiments of mercurification; and this proves how circumspect we ought to be in drawing conclusions.

**CCCLXIX. METALS and METALLISATION.**  
Under the general name *metal*, we comprehend here not only the metals properly so called, but also the semimetals; or all matters which have the essential metallic properties, which we shall here recount. Thus the word *metal* and *metallic substance* will be synonymous in this article.

Metallic substances form a class of bodies not very numerous, of very great importance in chemistry, medicine, arts, and the ordinary affairs of life. These substances have very peculiar properties, by which they differ from all other bodies.

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The natural bodies from which metals differ the least are earthy and pyritous matters, on account of their solidity and density. Metals and stones are, nevertheless, very different, the heaviest stones which are unmetallic being much lighter than the lightest metals. A cubic foot of marble weighs 252 pounds; and an equal bulk of tin, the lightest of metals, weighs 516 pounds. The difference is much greater when the weight of such a stone is compared with that of gold, a cubic foot of which is 1326 pounds.

Opacity is another quality which metals possess eminently; the opacity of metals being much greater than the opacity of any unmetallic substance.

This great opacity of metals is a consequence of their density, and these two properties produce a third, peculiar also to metals, namely, a capacity of reflecting infinitely more light than any other body: hence metals whose surfaces are polished, form mirrors representing the images of bodies, more clearly than any other matter. Thus looking-glasses produce their reflexion merely by the silvering, which is a covering of metal upon their surfaces. To this reflective property metals owe their peculiar lustre, called the *metallic lustre*.

Although the several metallic substances differ considerably in hardness and fusibility, we may say in general, that they are less hard and less fusible than pure earths.

Metals cannot unite with any earthy substance, not even with their own earths, when these are deprived of their metallic state: hence when they are melted, they naturally run into globes, as much as the absolute gravity of their mass, and their pressure upon the containing vessels, will allow. Accordingly, the surface of a metal in fusion is always convex. A metal in that state always endeavors to acquire a spherical form, which it does more perfectly as the mass is less. This effect is very sensible in quicksilver, which is nothing but a metal habitually fluid or fused. A mass of several pounds of mercury, contained in a shallow, wide-mouthed vessel, is so spread out, that its upper surface is almost flat, and the convexity is not very sensible but at its circumference: on the contrary, if we put very small masses of mercury into the same vessel, as, for instance, masses weighing a grain each, they become so round as to seem perfect globes. This effect is partly occasioned by the inaptitude of metals to unite with the vessels containing them when in fusion; by which quality the whole affinity which subsists betwixt the integrant parts of these metals is capable of acting; and partly also by this affinity, which disposes the integrant parts to come as near to each other as they can, and consequently to form a sphere.

This property is not peculiar to melted metals, but to all fluids, when contiguous to bodies solid or fluid, with which they have no tendency to unite. Thus, for instance, masses of water upon oily bodies, or oily masses upon bodies moistened with water, assume always a form so much nearer to the spherical as they are smaller. Even a large drop of oil poured upon a watery liquor, so that it shall be surrounded with this liquor, becomes a perfect sphere.

All metals are in general soluble by all acids; but often these solutions require particular treatment and circumstances, which are mentioned under the articles of the several metals. With acids, they form neutral salts with metallic bases. These salts have all more or less causticity, which proceeds from the little intimacy of union betwixt the acid and metal, and from the great weight of the latter substance. The affinity of metals is less than of absorbent earths

and alkaline salts to acids ; and therefore any metal may be separated from any acid by these earthy and saline alkalis.

Alkaline salts are capable of acting upon all metallic substances, and of keeping them dissolved by proper management.

Metals may in general be united with sulphur and liver of sulphur. With sulphur they form compounds resembling the peculiar substance of ores, which are generally nothing else than natural combinations of sulphur and metal. Metals have less affinity with sulphur than with acids ; hence sulphur may be separated from them by acids. Some exceptions from these general rules, concerning the affinity of metals to sulphur and liver of sulphur, and concerning their separation from sulphur by acids, may be seen under the articles of the several metals. But these exceptions do probably take place, only because we have not yet found the method of surmounting some obstacles which occur in the ordinary methods of treating certain metals.

All metals may in general be united with each other, with which they form different alloys which have peculiar properties ; but this rule also is not without some exceptions. See *ALLAY and AMALGAM*.

Metals have strong affinity with the inflammable principle, and are capable of receiving it superabundantly.

Lastly, oily substances seem to be capable of acting upon all metals. Some metals are easily and copiously dissolved by oils, and perhaps they might all be found to be entirely soluble in oils, if the methods known in chemistry were tried for the accomplishment of these solutions.

The properties above-mentioned agree in general to all metallic substances : but, besides the properties peculiar to each metal, some properties are common to a certain number of them ; and hence they have been divided into several classes.

Those metallic matters which, when struck by a hammer, or strongly compressed, are extended, lengthened, and flattened, without being broken, (which property is called *ductility* or *malleability*) and which also remain fixed in the most violent and long continued fire, without diminution of weight, or other sensible alteration, are called *perfect metals*. These perfect metals are three ; *gold, silver, platina*.

The metallic matters which are ductile and fixed in the fire, to a certain degree, but which are destroyed by the continued action of fire, that is, changed into an earth deprived of all the characteristic properties of metals, are called *imperfect metals*. Of this kind are four ; *copper, iron, tin, lead*.

The metallic substances which, as well as the imperfect metals, lose their metallic properties by exposure to fire, but which also have no ductility nor fixity, are distinguished from the others by the name of *semi-metals*. Of this class are five ; *regulus of antimony, bismuth, zinc, regulus of cobalt, and regulus of arsenic*.

Lastly, mercury, which has all the general properties of metals, makes a class separate from the others ; because in purity and gravity it is similar to the perfect metals, and in volatility to the semi-metals. Its fusibility also so far surpasses that of any other metallic matter, that it is sufficient to distinguish it from all, and to give it a distinct class. We have enumerated, therefore, in all, thirteen metallic substances, two of which only were unknown to the ancients

cients, namely, platina and regulus of cobalt. We have reason to wonder that these two metallic bodies, and particularly platina, which is a perfect metal, should have remained unknown till lately.

This may give us cause to hope, that if natural history and chemistry be carefully cultivated, as they have been since the renovation of the sciences, we may still make essential discoveries in this way. Mr. Cronstedt has given, in the Swedish Memoirs, a description of a metallic matter, which, as he says, appears to be a new semimetal distinct from the others. In that case, this would be the fourteenth metallic matter known, and the third lately discovered: but as, since the Memoir of Mr. Cronstedt, this new semimetal has not been examined by chemists, it is yet but little known; and therefore further experiments seem requisite to decide whether it ought to be admitted as a new semimetal. (y)

As chemists can only know compound bodies by being capable of separating the principles of such bodies, and even of re-uniting their principles so as to reproduce such compounds as they were originally; and as hitherto they have not been able to accomplish any such decomposition upon the perfect metals; hence, if all the other metallic substances were equally inalterable, we should be very far from having certain notions concerning metals in general: but if we except gold, silver, and platina, all the other metallic matters are susceptible of decomposition and of recomposition, at least to a certain degree; and the experiments of this kind made by chemists, and chiefly by the modern chemists, have thrown much light on this important subject.

We may observe, that even if we had not been able to decompose any metallic substance, we might still, by reflecting on the essential properties of metals, discover sufficiently well the nature of their principles.

The solidity, the consistence, and especially the gravity which they possess in a degree so superior to all other bodies, would not have allowed us to doubt that the earthy element, of which these are the characteristic properties, enters largely into their composition, and makes their basis.

The facility with which they combine with almost all inflammable matters, and with all those which have great affinity with phlogiston, such as acids; joined to their incapacity of being allayed with meagre matters that are purely earthy or purely watery, which have no disposition to unite with phlogiston; would also have furnished very strong motives to believe, that the inflammable principle enters largely into the composition of metals.

We must acknowledge, however, that these considerations would only have furnished concerning the existence of the inflammable principle in metals, but a simple probability, very far from the compleat proof we now have: but the combustibility of all metals capable of decomposition by this method, and of a subsequent reduction with all their properties, by the rejunction of the inflammable principle, furnishes the clearest and the most satisfactory demonstration that we have in chemistry. We shall now mention what is known upon this subject, and the consequences necessarily resulting.

(y) *See* NICKEL. Mr. *Juss* pretends that he has discovered a new metallic substance contained in yellow mica. This he says was of a blackish-grey color; but when mixed with gold heightened the tints, without destroying the malleability of that metal, though itself is brittle.

The destructible metals present exactly the same phenomena as all other bodies containing the inflammable principle do, in the state of combustion. When exposed to fire, without access of air, that is, in close vessels, they become red-hot, melt, or sublime, according to their nature: but they receive no alteration in their composition from fire applied in this manner, and they are afterwards found to be exactly in the same state as before. In this respect, they resemble perfectly all bodies which contain no other inflammable matter than pure phlogiston.

But when imperfect metals are exposed to fire, with access of air, as, for instance, under a muffle in a furnace which is made very hot, then they burn more or less sensibly, as their inflammable principle is more or less abundant, or more or less combined. Some of them, as iron and zinc, burn with a very lively and brilliant flame; but this flame is of the same nature as that of charcoal, of sulphur, of all bodies, the combustible principle of which is pure phlogiston, and is not in an oily state, that is, furnishes no foot capable of blackening.

Also the imperfect metals detonate with nitre, when all the circumstances which that detonation requires are united. *See DETONATION of NITRE.* Their phlogiston is consumed by this method much more quickly and completely than by ordinary calcination or combustion. Their flame is also much more lively and brilliant; and some of them, as iron and zinc, are used in compositions for fireworks, from their very vivid and beautiful flame.

Nitre is alkalised by these metallic detonations exactly in the same manner as, in its detonation by coals.

Lastly, imperfect metals being treated with acids which have an affinity with phlogiston, that is, with the vitriolic and nitrous acids, are deprived also by these acids of a more or less considerable part of their inflammable principle: They give a sulphureous quality to vitriolic acid, and are even capable of furnishing sulphur with that acid.

Although the experiments now mentioned were the only proofs of the existence of an inflammable principle in metallic substances, these would be sufficient to establish it incontestibly. But we shall see, when we continue to examine the phenomena attending the decomposition of metals, that those are not the only proofs.

If the inflammable matter which shews itself so evidently in the burning of metals, is really one of their constituent parts, their essential properties must be altered in proportion to the quantity of it taken from them; and this evidently happens upon trial; for the residuum of metallic matters, after calcination, departs from the metallic character, and approaches to the nature of mere earth. The opacity, brilliancy, ductility, gravity, fusibility, volatility, in a word, all the properties by which metallic substances differ from simple earths, diminish or entirely disappear, by taking from them their inflammable principle; so that when their calcination has been carried as far as is possible, they resemble mere earths, and have no longer any thing in common with metals. These earths can no longer be combined with acids or with metals, but are capable of uniting with pure earths. They are then called *calxes* or *metallic earths*. *See CALXES (METALLIC).*

We must observe concerning the decomposition of metals, 1. That when only a small quantity of inflammable principle is taken from metals, a small quantity only of calx is formed, and the remaining part continues in the metallic state: hence, as the portion of calcined metal can no longer remain united with the undestroyed metal, it separates in form of scales from the surface of the metal, when the calcination has been performed without fusion, as generally happens to iron and to copper; or these scales float upon the surface of the melted metal when the calcination is performed during fusion, because the calx is specifically lighter than the metal, as happens to the very fusible metals, as tin, lead, and most of the femimetals.

2. The imperfect metals are not all equally easily and completely calcinable. In general, as much of their phlogiston may be easily taken from them, as is sufficient to deprive them of their metallic properties; but the remaining portion of their phlogiston cannot so easily be driven from them. Some of them, as copper, resist the first calcination more than the rest; and others, as lead and bismuth, may be very easily calcined, but only to a certain degree, and retain always obstinately the last portions of their inflammable principle; lastly, others, as tin and regulus of antimony, may not only be easily and quickly calcined, but also much more completely. All the other metals partake more or less of these properties relating to their calcination. In general, if we except the labors of alchemists, which are not much to be depended upon, we have not yet made all the proper efforts to arrive at a perfect calcination of the several metallic substances; which, however, is absolutely necessary, before we can arrive at a complete knowledge of the nature of their earths, as we shall afterwards see.

When metallic earths have lost but little of their phlogiston, and are exposed to strong fire, they melt and are reduced to compact masses, still heavy and opaque, although much less so than the metals, and always brittle and absolutely unmanageable. If the calcination has been more perfect, the metallic earths are still fusible by fire, but less easily, and convertible into brittle and transparent masses possessed of all the properties of glass, and are accordingly called *metallic glasses*. These glasses do not possess any of the properties of their metals, excepting that they are specifically heavier than other glasses, that they are capable of being attacked by acids, and that the glasses of the femimetals are somewhat less fixed than unmetallic glasses. Lastly, when the calcination of metals has been carried to its greatest height, their earths are absolutely fixed, and unfusible in the fire of our furnaces, and possess no longer the solubility in acids by which metals are characterised.

These are the principal changes which metals suffer by losing their phlogiston. They are thus changed into substances which have no properties but those of earth. This is a certain proof that the inflammable principle is one of their constituent parts. But we have also other proofs of this important truth. The reduction of metallic calxes into metal, by the addition of phlogiston alone, completes the proof; and the whole forms one of the clearest and most satisfactory demonstrations in all the sciences. This reduction is effected in the following manner.

If the earth of a metal be mixed with any inflammable matter, which either is, or can be changed into the state of coal, together with some salt capable of

facilitating fusion, but which, from its quantity or quality, is incapable of receiving the inflammable principle; and if the whole be put into a crucible, and the fusion promoted by a fire gradually raised; then an effervescence will happen, accompanied with a hissing noise, which continues a certain time, during which the fire is not to be encreased; afterwards, when the whole has been well fused, and the crucible taken from the fire and cooled, we shall find at the bottom, upon breaking it, the metal, the earth of which was employed for the operation, possessed of all the properties which it had before calcination and reduction. *See REDUCTION.*

We cannot doubt that this wonderful transformation of an earthy substance into a metal is solely caused by the phlogiston passing from the inflammable matter to the metallic earth; for, first, in whatever manner, and with whatever substance metallic earths be treated, they cannot be ever reduced into metals without a concurrence of some substance containing phlogiston. 2dly, The nature of the substance which is to furnish phlogiston is quite indifferent, because this principle is the same in all bodies containing it. 3. Lastly, if after the operation the substance furnishing the phlogiston be examined, we shall find that it has lost as much of that principle as the metallic earth has received.

The facts related concerning the decomposition and the recomposition of metals prove incontestably, that they are all composed of earth and phlogiston. But we do not yet certainly know whether these two be the only principles of metals. We might affirm this, if we could produce metals by combining phlogiston with some matter which is certainly known to be simple earth. But this hitherto has not been accomplished; for if we try to treat any earth, which has never been metallic, with inflammable matters, we shall perceive that these simple earths are not combinable with phlogiston, so as to form metals. We shall even perceive that the metallic earths resist this combination, and are incapable of reduction into metal, when they have been so much calcined as very nearly to approximate the nature of simple earths.

These considerations, added to this, that we cannot easily conceive how, from only two certain principles, so many very different compounds as the several metallic substances are, should result, are capable of inducing a belief that some other principle is added to these two already mentioned in the composition of metals.

Many great chemists, and particularly Becker and Stahl, seem to be convinced of this opinion; and chiefly from the experiments concerning the mercurification of metals, they believe that this third principle exists copiously in mercury; that it is of a mercurial nature; that it also exists in marine acid, to which it gives its specific character; that by extracting this mercurial principle from marine acid, or any other body containing it copiously, and by combining it with simple earths, these may acquire a metallic character, and be rendered capable of receiving phlogiston, and of being completely metallised.

These chemists admit also, and with probability, a different proportion of metallic principles in the several metals, and believe, that particularly the principle which they call *mercurial earth* exists more copiously and sensibly in certain metals than in others. The most mercurial metals, according to them, are mercury, silver, lead, and arsenic. Most chemists distinguish from the



the other metals, silver, mercury, and lead; which they call *white metals*, *lunar metals*, or *mercurial metals*.

All these considerations being united, and others too many to be mentioned, give some probability to the existence of the mercurial principle in metals. We must however acknowledge, that the existence of this principle is only merely probable, and, as Stahl observes, is not nearly so well demonstrated as that of the inflammable principle: we may even add, that we have strong motives to doubt of this existence.

As marine acid, mercury, arsenic, and even the other substances in which the mercurial earth is supposed to abound, are very volatile, and that none of the properties attributed to it shew that it is fixed, it seems, if it does exist, to be necessarily volatile. The chemists who admit it, consider it as volatile, since one of the methods best attested for the mercurification of metals is by subliming them through charcoal in Geber's manner, and since it is chiefly in the foot formed by the metals, that chemists look for their mercurial principle.

If then the mercurial earth be a volatile principle; when metals are decomposed by combustion, or by detonation with nitre, a considerable part of this volatile mercurial principle must be dissipated. Hence we ought not to be able to remetallicise the calxes of metals, without recombining not only their lost phlogiston, but also their lost mercurial earth. But from experience we know, that by addition of phlogiston alone these calxes may be metallised, and that no mercurial principle is necessary. We cannot answer to this difficulty, that all substances containing phlogiston contain also a sufficient quantity of mercurial earth for the reduction of metallic calxes; for if that were true, we should be able to produce metals by treating unmetallic earths with inflammable matters, since in such a combination all the principles of metals would be present. But we have already observed, that this cannot be done.

When indeed metallic calxes are reduced, there is always some loss of quantity, as the same weight of metal is never procured which existed previously to the calcination; and also the more complete the calcination has been, this loss of weight will be so much the more considerable. We may consequently attribute this loss to that of the mercurial principle, during the decomposition of the metal, and which is not restored to it by reduction with phlogiston alone.

But may we not as reasonably believe, that if ordinary earths, or even metallic earths perfectly calcined, cannot be metallised, this proceeds only from the difficulty of commencing an union with substances so different as earth and phlogiston? but when this union is once begun by nature, the earth is then much more disposed to combine intimately with a sufficient quantity of phlogiston to constitute it a metal; that thus any earth, entirely free from phlogiston intimately combined, is, relatively to us, an unmetallic earth, whether it be naturally found in that state, as almost all substances are, which we call simply *earths*, or whether it be a metallic substance perfectly calcined. Hence the mercurial earth would be nothing else than phlogiston, or rather is not a distinct substance, since it consists only in a beginning of union of phlogiston with earth, or in a disposition which an earth has of uniting intimately with the inflammable principle. This is an idea of the celebrated Henkel, whom

we certainly cannot suspect of indifference or incredulity concerning the possibility of the artificial production of metals.

If this opinion were well grounded and proved, the artificial production of metals would be, in fact, not only possible, but much less difficult than has hitherto been believed; for only two principles are, in this case, necessary to be combined to form a metal. We should then have nothing to do with the mercurial principle, the most troublesome of all, the most untractable, the least distinctly known, and the existence of which is not even ascertained.

But notwithstanding these considerations, we must not believe that the production of metals is not one of the most difficult problems in chemistry. The reflexions we shall add upon this subject will be sufficient demonstration to every sensible person, that great knowledge is requisite in that science, to attempt with any hopes of success, the production even of the most imperfect semimetal; they will shew the folly of those who attempt to make gold and silver, without being possessed of any knowledge even of elementary chemistry, which they despise and call *vulgar chemistry*, of which they disdain to inform themselves, although elementary knowledge be in chemistry, as in every other science, the most essential, fundamental, and necessary for further attainments. By a singular fatality, the most ignorant persons are the most presuming. They who see what passes in the particular assemblies of the Academy of Sciences, know that this illustrious society is always beset with pretenders to geometry, who really believe they have discovered the quadrature of a circle, the perpetual motion, &c. and who at the same time are so ignorant of the first elements of algebra and geometry, that they are incapable of perceiving the demonstrations of their errors. Happily the persons who imagine that they have discovered the means of making gold, are not so communicative, and keep their secrets in hopes of enriching themselves, otherwise the Academy would be as much importuned by the adepts of the philosophers stone, as it is now by the squarers of a circle.

To return to the artificial production of metals, we must observe, that even if we were certain, that it depends only on the intimate combination of the inflammable principle with a matter simply earthy, we should labor by chance, and without any reasonable expectation of success, if we were to attempt that combination, without having more knowledge than we now possess, concerning the true nature of the earthy principle which enters into the composition of metals; for we must acknowledge that chemistry has made but little progress in this matter.

Metallic substances, although they resemble each other by the general properties mentioned in the beginning of this article, differ nevertheless from each other very evidently by the properties peculiar to each. Do these differences proceed from the different proportion, and from the more or less intimate connexion of the inflammable principle with the earthy principle; supposing that this latter should be essentially the same in all metals? or ought they to be attributed to the difference of earths, which, in that case, would be distinct and peculiar to each metal? or, lastly, do metals differ from each other, both by the nature of their earths, and by the proportion and intimacy of connexion of their principles? All these things are entirely unknown, and we may easily perceive, that till they are known, we cannot discover what method to pursue

pursue in our attempts to accomplish the combinations we are now treating of.

The most essential point then is to arrive at a knowledge of the true nature of the earths which are in metals; and the only method of arriving at this knowledge is, to reduce them to their greatest simplicity by a perfect calcination. But this cannot be accomplished but by long and difficult operations. We have seen above, that all metals are not calcinable with equal ease; that the perfect metals have not been hitherto calcined truly, by any process; and that in general the last portions of phlogiston adhere very strongly to calcinable metals.

Some metals, however, as tin and regulus of antimony, may be easily calcined so as to be rendered irreducible. By carrying the calcination still further, by the methods known in chemistry, we might obtain their earths so pure, that all their essential properties may be discovered, by which they might easily be compared together. This comparison would decide whether their nature be essentially different, or not.

If they were found to be composed of earths essentially the same, we might next proceed to compare metallic with unmetallic earths. If the former were found similar to some of the latter kind, we should be then assured that the earth of metals is not peculiar to them, and that ordinary unmetallic earths are susceptible of metallification.

The greater the number of metals operated upon, the more general and certain the consequences resulting from these would be; so that, for instance, if the operation were extended to all calcinable metals, and if the result of each of these operations were, that the calxes, when perfectly dephlogisticated, do not differ from each other, and are similar to earths already known, we might conclude from analogy, and we should be almost certain, that the earths of the perfect metals are also of the same nature.

They who know the extent and difficulties of chemical operations, will easily perceive that this would be one of the most considerable. Nevertheless, after having determined this essential point, we should only have done half our work. For a knowledge of the nature of the earth of metals, and where it is to be found, would not be sufficient; we must further endeavor to find a method of combining with this earth a sufficient quantity of phlogiston, and in a manner sufficiently intimate, that a metal might be formed by such a combination. We here always suppose, that earth and phlogiston are the two only principles of metals. I say, then, that the method of combining these two principles must be discovered; for we know that the ordinary processes, those, for example, which are employed for the reduction of metals, are insufficient in this case. But this second difficulty is perhaps greater than the former.

When we reflect on the fundamental rules of the union of bodies, we shall discover a road which may lead to this combination. In fact, if it be true, as every thing seems to demonstrate, that all natural substances may be united together, and that the resistance made by some to this union proceeds from the too strong union of their integrant parts, then the difficulties which occur in attempting to combine intimately phlogiston with earth, which of all known substances has the strongest aggregation, can only proceed from the too great adhesion

hesion of the integrant parts of earth to each other. Hence the only method of disposing to this union, is to separate and insulate the primary integrant parts sufficiently, and to break the aggregation as much as is possible.

The integrant parts of earth may indeed be well disjoined, when fused by a strong heat: therefore, if it were possible to fuse perfectly a simple earth, previously mixed with some inflammable matter, and put into a vessel accurately closed (which circumstance is absolutely necessary to prevent the combustion of the inflammable principle) the phlogiston would probably unite intimately with this earth, and a metallic matter would result from it. But this method seems to be impracticable, because simple earths are too refractory to be fused without addition, by the strongest fire which can be made in furnaces.

We may indeed facilitate, as much as we please, the fusion of earths, by the addition of saline fluxes; but this method, which succeeds very well for the reduction of metallic earths, when they have not been too much dephlogisticated, and when therefore they preserve a disposition to be metallized, becomes insufficient to reduce these earths, when they have been too much calcined; and it must be much more insufficient with regard to simple earths, which have never been in a metallic state.

The reason of this is, that to procure the union of one body with another, not only the aggregation of that body must be broken, but also when this disjunction of aggregation is occasioned or facilitated, as in the present case, by the interposition of the parts of some substance, this substance must not have a too great affinity with the body to be united to that whose aggregation is broken, as may easily be understood.

But we are certain that all the saline matters, which may be employed to facilitate the fusion of earths, have themselves a very great affinity with the inflammable principle; and the greater this affinity is, the more it ought to weaken the tendency which the inflammable principle has to be combined with the parts of earth.

Here then is a compensation. For if, on one side, the salts, while they facilitate the fusion of the earth, place it in a more favorable state for combination with phlogiston; on the other side, the affinity of these salts with phlogiston diminishes in the same proportion the disposition which the phlogiston has of combining with the earth; and therefore we need not wonder that this combination should not take place.

But the case is different, when the earth intended to be metallized by the addition of phlogiston, is previously united intimately with a certain quantity of that principle, as happens in metallic calxes not perfectly dephlogisticated. For this phlogiston, strictly united with the earth, not only much diminishes the force of its aggregation, but it must also necessarily facilitate very greatly the accretion of a new quantity of phlogiston, from the strong disposition of bodies to unite with others of the same nature.

Hence we cannot hope to succeed in trials of this kind by fusion with an intense fire: but these are not the only resources which chemistry offers to us. We are very certain, that the metallic combinations formed daily by nature, are not effected by violent fusions. Water kept in a fluid state by the little heat necessary for that purpose, is itself capable of keeping the integrant parts of  
bodies

bodies whose aggregation is broken, suspended and insulated from each other, and those of earth, as well as of other substances, as is evidently demonstrated by sediments, stalactites, crystallizations, stones of all sorts, which are formed every where by water. Water also of all substances has the least affinity with phlogiston, and consequently has all the requisite conditions as a vehicle, to assist the combination of earth with phlogiston: Lastly, we know from experience that metals may be decomposed, and that their calxes may be metallised as well by the humid as by the dry way. *See* REDUCTION.

Water, then, seems to be a very proper intermediate substance to form the first rudiments of metallisation, and is employed by nature for the production of metals, minerals, and of all the compound bodies that we see. According to the opinion of one of our greatest naturalists and philosophers, nature makes with water all that we make in our laboratories with fire, and many others which we cannot accomplish. Water is her principal and almost only instrument. By water, therefore, that is, by the humid way, the combinations now in question ought to be attempted.

But, it may be said, nature employs an almost infinitely long time for most of her productions, and particularly for metallic combinations. Can this time be shortened by chemical means? Does chemistry furnish a method of impregnating water with the primitive integrant molecules of earth, and with a sufficient quantity of inflammable principle? We have reason to presume it. Nevertheless, to be able to affirm any thing upon this subject, a person ought to have made experiments with these views, which, I confess, I never have done.

We shall not enter into a further detail upon this matter, that we may not prolong this discussion, perhaps too long already, and too conjectural for a work of this nature. We thought some extent ought to be given to it, not only because the subject is itself interesting, but also because many persons, particularly those who are ignorant of the whole extent of chemistry, consider metallisation as the sole object of that science. It has been almost the sole end of chemists, from time immemorial to the renovation of the sciences, that is, to late times.

All the ancient chemists were solely engaged about metals. Their views and inquiries were so directed to that point, that they entirely neglected whatever was not connected with it, so that the name of chemist gave the idea of a man who endeavored to make metals. The insuperable obstacles they have met, have obliged them to multiply their experiments, and to work upon many bodies besides metals. The properties of many substances have been thus discovered successively, and these multiplied discoveries, having been afterwards generalised, and arranged, have given birth to the philosophical chemistry now cultivated; to that chemistry which explains clearly, which proceeds with order and method, and which in this respect differs greatly from the ancient references concerning the philosopher's stone.

We do not now undertake with the same confidence and ardor as heretofore the solution of the most difficult problems. The slow and circumspect progress of chemistry appears humble and timid, in comparison of the bold and rapid course of ancient chemistry: but such is the consequence of experience and reflection.

When men have long wandered at random; when, after they have fatigued themselves with every trial that occurred, without rule or measure, they have failed in their attempts; their most reasonable conduct is to return as they came, to begin afresh, and not to engage in the pursuit till the proper road be well ascertained.

We do not consider as certain guides the ideas which the nature of the subject, and the desire of contributing to the advancement of the art, and of inspiring a true taste for it, have induced us to suggest on metallisation in this article. If, in pursuing these ideas, we should be able to produce the rudest beginning of a metal or semimetal, true chemists would certainly find much cause of astonishment and admiration. Much farther are we from presuming that by this method the perfect metals, as gold and silver, can be produced. We do not intend to excite too flattering hopes, but only to present a rational plan of such labors, and to shew the difficulties to those who chuse to undertake them.

We ought to advertise here, that some famous chemical processes have been considered by many as metallisations, but which are really not so. Such is Beccher's famous experiment of the *Minera arcuaria perpetua*, by which that chemist proposed to the States General to extract gold from any kind of sand. Such also is the process of Beccher and of Geoffroy, to obtain iron from all clays by treating them with linseed oil in close vessels. In these, and many other such processes, we do only obtain metal that was already formed. Every earth and sand, as the intelligent and judicious Cramer observes, contain some particles of gold. Clays do not commonly contain iron ready formed, but all of them contain a ferruginous earth, naturally disposed to metallisation. *See* CLAY. Accordingly we must conclude, that, by Mr. Geoffroy's experiment, iron is only reduced or revived, but is not produced.

The great difficulties which occur in attempting to give a metallic quality to simple earths have induced a belief, that the nature of metals ready formed might be more easily changed, and the less perfect brought to a more perfect state. To effect this, which is one of the principal objects of alchemy, and is called transmutation, numberless trials have been made. As we have not any certain knowledge of what occasions the specific differences of metallic substances, we cannot decide whether transmutation be possible or not. In fact, if each metallic substance have its peculiar earth, essentially different from the earths of the others, and consequently if the differences of metals proceed from the differences of their earths; then, as we cannot change the essential properties of any simple substance, transmutation of metals must be impossible. But if the earths and other principles of metals be essentially the same, if they be combined in different proportions only, and more or less strictly united, and if this be the only cause of the specific difference of metals, we then see no impossibility in their transmutation.

Whatever be the cause of the differences of metals, their transmutation seems to be no less difficult than the production of a new metallic substance, and perhaps it is even more difficult. Alchemists, whom nothing astonishes or embarrasses, believe that transmutation is possible, and they even affirm that they have effected it. They begin by supposing that all metals are composed of the same principles, and that the imperfect metals do not differ from gold and silver.

but because their principles are not so well combined, or because they contain heterogeneous matters. We have then only these two faults to remedy, which, as they say, may be done by a proper coction, and by separating the pure from the impure. As we have but very vague and superficial notions concerning the causes of the differences of metals, we confess that we cannot make any reasonable conjecture upon this matter; and we shall only advise those who would proceed upon good principles, to determine previously, if metals have each a peculiar earth, or only one common to them all. In the second place, if it should be demonstrated that the earthy principle is the same in all metals, and if that be demonstrated as clearly as the identity of the inflammable principle in metals is proved; they must then determine whether these two be the only principles in metals, whether the mercurial principle exists, and whether it be essential to all metals, or to some only, and what is the proportion of these two or three principles in the several metallic substances. When we shall clearly understand these principal objects, we may then be able to determine concerning the possibility of transmutation; and if the possibility should be affirmed, we shall then begin to discover the road which we ought to pursue.

We have no reason to believe that any other principle enters into the composition of metals than those above-mentioned; no vestige is perceptible of either air or water. Some chemists have nevertheless advanced that they contain a saline principle. If that were true, they would also contain a watery principle. But all the experiments adduced to prove this opinion are either false, or only shew the presence of some saline particles extraneous to the metals, or contained unknown to the chemists in the substances employed in the experiments. For metals perfectly pure, subjected to all trials with substances which do not contain, and which cannot produce any thing saline, do not discover any saline property. We must however except arsenic, and even its regulus, these being singular substances, in which the saline are as sensible as the metallic properties.

Arsenic seems to be one of those intermediate substances which nature has placed in almost all its productions betwixt two different kinds, and which partake of the properties of each kind. Arsenic thus placed betwixt metallic and saline substances has properties common to both these kinds of substances, without being either entirely a metal or a salt. *See ARSENIC.*

As water seems to act to a certain degree upon iron, even without the concurrence of air, as the operation of martial ethiops shews, we might thence suspect something saline in that metal. Nevertheless, I do not believe that what happens in that operation has been so well explained, that any certain consequences can be deduced. 1. The water employed ought to be perfectly pure, that is, distilled rain water. 2. The iron employed ought also to be perfectly pure, and such is very difficultly to be procured. 3. The operation ought to be performed in a bottle accurately closed, that we may be assured that the air contributes nothing to the action upon the iron. 4. After the water has remained a long time, suppose a year, upon the iron, the water ought to be carefully filtrated and examined, to ascertain whether it really has dissolved any part of the metal.

In the mean time, we may conclude that metals do not seem to contain any saline principle. And when we consider well their general properties, they

seem to be nothing else than earths combined more or less intimately with a large quantity of phlogiston. Although we can demonstrate that their inflammable principle is not in an oily state; and that it is pure phlogiston, they have nevertheless an oily appearance, in this circumstance, that they adhere no more than oils to earthy and aqueous substances, and that they always assume a globular figure when supported by these substances entirely free from phlogiston.

This resemblance is so sensible, that chemists, before they knew the nature of phlogiston, believed that metals contained an oily and fat matter; and even now many persons, who talk of chemistry without understanding it, speak of the *oil, or fat of metals*; expressions, which do not sound well to genuine chemists. The cause of this quality of metals is the quantity of phlogiston which they contain. Sulphur, phosphorus, oils, and even fats, have this appearance merely from the inflammable principle which enters into their composition: for this property is communicated by that principle to every compound which contains a certain quantity of it. See PHLOGISTON.

When the phlogiston combines copiously and intimately with earthy matters so as to form metals, it probably so disposes them that the primitive integrant parts of the new compound, that is, of the metal, approximate and touch each other much more than the integrant parts of simple earths can. This is proved by the great density or specific gravity, and other general properties, of metals.

In fact, as we cannot conceive that a body should be transparent, unless it have pores and interstices through which rays of light can pass, therefore the more dense a body is, that is, the fewer such interstices it has, the less transparent it will be; so that the densest bodies ought to be the most opaque; as in metals. The disposition of the pores of bodies contributes also much to their greater or less transparency; and bodies, the pores of which are continued and straight, are more transparent than those whose pores are interrupted, transverse, or oblique; so that a body may be much more transparent than another which is less dense; as we see that glass is more transparent than charcoal. But when other circumstances are equal, the densest bodies are the most opaque. Therefore the opacity of bodies is proportionable to their density, and to the deviation of their pores from right and parallel lines.

From the great opacity of metals, they probably possess both these qualities in an eminent degree. We have seen, at the beginning of this article, that the lustre of metals and their property of reflecting light much better than any other substance, are necessary consequences of their opacity. This is also self-evident, because the fewer rays any bodies can transmit, the more it must reflect.

Lastly, the ductility of metals proceeds also from their density, and from the disposition of their pores, as we have explained under the word DUCTILITY. Phlogiston also appears to communicate ductility to most of the bodies containing it, as we see in sulphur, and unknown bodies, as resins, wax, &c. all which are more or less ductile, at least when heated to a certain degree. Lastly, the softness, fusibility, and volatility of which all metals possess more or less, and which many of them possess in a superior degree, being properties entirely contrary to those of the earthy principle, probably proceed from the inflammable principle. In general, if we reflect on the essential properties of the earthy and inflammable



able principles, we shall easily perceive that these properties, being combined and modified by each other, ought to produce the properties of metals. In order therefore to understand all this article, the words EARTH and PHLOGISTON ought to be consulted.

The order in which metals compared with each other possess most eminently their principal properties, is the same as that in which they are here enumerated, beginning always with that metal in which the property is most considerable.

1. *Specific gravity or density.* Gold, platina, mercury, lead, silver, copper, iron, and tin.

2. *Opacity.* We cannot well compare metals with each other in this respect, because it is so considerable in all that it seems complete. If, however, they differ in this respect, the same order will serve for opacity as for density.

3. *Metallic lustre or brilliancy.* The same observation which was made concerning the last-mentioned property is applicable to this also. We must however observe, that as, by polish, bodies are rendered brighter, and that as whiteness contributes much to the reflexion of light, the whitest and hardest metals therefore reflect best. Hence platina ought to be placed first, and then iron or rather steel, silver, gold, copper, tin, lead. (x)

4. *Ductility.* Gold, silver, copper, iron, tin, lead. The ductility of mercury and of platina are not yet determined.

5. *Hardness.* Iron, platina, copper, silver, gold, tin and lead.

6. *Tenacity.* By tenacity we understand the force with which the integrant parts of metals resist their separation. This force appears to be in a compound ratio of their ductility and hardness. The comparative tenacity of metals is measured by the weight which wires of the same diameter, made of the several metals, can sustain without breaking. Gold is the most tenacious, then iron, copper, silver, tin, lead. The tenacity of mercury is unknown: That of platina is not yet determined, but is probably considerable.

7. *Fusibility.* Mercury, tin, lead, silver, gold, copper, iron, and lastly platina, which cannot be fused by the greatest fire of our furnaces, but only by the solar focus, as Messrs. Macquer and Berthollet have determined.

(x) Hardness of metals may contribute much to the duration of their polish; but certainly soft metals, if their texture be equally compact, are no less capable of receiving a polish than hard metals. Some hard metallic alloys have been found to be less liable to tarnish than softer compounds, and have for this reason also been chiefly used for speculums. The property of reflecting light seems chiefly to depend on the closeness of the particles, or on the density, on the smoothness of the surface, and on the color being most similar to the color of the light to be reflected. The whitest metals, silver, mercury, tin, reflect light more abundantly than others. Gold being the densest metal, and perhaps because the color of gold is nearest a slightly-

yellowish tinge, does also reflect light very copiously. Hence speculums made of leaf-gold have been found to be very effectual. Iron or steel reflects much less light than any of the above-mentioned metals, although the author has considered it as capable of a greater reflective power. Platina is generally in so small grains, that its reflective power cannot easily be determined. The precise degrees of that power which ought to be assigned to each of the above-mentioned metals, cannot without accurate experiments be ascertained. However, I think, their reflective powers will be found to be more nearly in the following order, than in that mentioned in the text. Silver, quicksilver, tin, gold, copper, iron, lead.

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The table of affinities of Mr. Geoffroy gives for metallic substances in general, marine acid, vitriolic acid, nitrous acid, vegetable acid. Mr. Gellert's table contains no column for metallic substances in general.

The uses of metals are numberless and great. Their particular uses shall be mentioned under the articles of the several metallic substances.

CCCCCL. M I C A. (a)

CCCCLI. M I L F O I L. (b)

CCCCLI. M I L K, and W H E Y. The milk of animals is a white liquor composed of three very different substances, namely, butter, cheese, and whey. These three matters are intimately mixed with each other in fresh milk. Whey is the only fluid part of milk. Butter and cheese, which are mixed with it, have each of them a certain solidity, and are not soluble by whey. These two matters, the former of which is entirely of an oily nature, and the second is gelatinous or mucilaginous, are only interposed and suspended in the serous part by being very much divided.

Hence we see that milk is a true emulsion. Butter composes its oily part, which by the interposition of its particles gives an opaque white color; the cheese serves as a mucilage to keep the oily part suspended; and, lastly, whey, which is naturally transparent, is the aqueous substance, which is a vehicle for the other two. Milk may then be justly called an animal emulsion. From its properties we shall see that this name suits it in every respect.

Milk, recently taken from a frugivorous animal in good health, and fed with proper aliments, gives not by chemical trials any marks of an acid or alkaline quality. It has a sweet, agreeable, and somewhat saccharine taste; it contains no parts that are volatile with the heat of boiling water, at least in any sensible quantity, so as to be collected. Its smell, which is peculiar to it, is very weak.

This liquor is very susceptible of alteration; the smallest quantity of acid is capable of coagulating it. When an alkali is mixed with it, a kind of coagulation happens, which is very different from that which is occasioned by an acid.

(a) MICA, or *Talk*, is an earthy or stony substance consisting of thin, flexible, shining plates. These plates by exposure to fire become brittle, crumple, and by violent heat are vitrifiable. See Mr. D'Arcet's Memoir on the effects of a long and violent fire. Mica is either white and transparent; or it is colored, red, brown, green, or black, and semi-transparent. The colored micas generally contain some metallic matters, chiefly iron, and as Mr. Justi says, a new metallic substance [see the last note (y)], and are much more fusible than those which are white and colorless. Micas have a soft touch resembling that of unctuous substances. They are not soluble by acids, they are incapable of eliciting sparks when struck by steel, as flints do, or of forming a tenacious paste with water, as clay does; or of hardening, when mixed with water, as gypsum does. Mica is therefore neither a calcareous, siliceous, argil-

laceous, nor gypseous earth. The colorless transparent mica, called *Muscovite-glass*, is used as panes for windows. In Jemmland, a crumpled kind of mica is manufactured into kettles and other vessels, and also for hearths. The powder of this stone is mixed with sea-salt, and from the mixture marine acid is obtained by distillation.

(b) MILFOIL, or YARROW. The flowers and tops of the common purplish-flowered milfoil afford a blue oil similar to that of camomile. These flowers have an aromatic and not disagreeable smell, and somewhat of a rough, bitter and pungent taste. The bitterness and astringency remain in the extracts made by water or by spirit. From an ounce of milfoil-tops, water extracted three drams and a scruple, and spirit extracted from the same quantity two drams and a half. *Neuman.*

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This difference proceeds from the action of the alkali upon all the parts of the milk, and especially upon the butyraceous part, to which it gives a saponaceous quality.

Milk also very readily suffers several remarkable changes, without addition of other substance. The oily or butyraceous parts of the milk, being specifically lighter than the rest, and adhering but weakly, separate in great quantity by rest alone, and are collected on the surface, precisely as the oily parts separate from emulsions. They there form what is called *cream*, from which, when collected, butter is made. Milk is also susceptible of a spontaneous fermentation, by which it becomes acid, and is coagulated.

The coagulation of milk occasions a distinct separation of the caseous part from the serous; and as this latter continues to separate, the former acquires a greater solidity. By coagulation then, these two parts of milk are obtained separately from each other. But the manner, in which this coagulation is made, produces considerable differences in the qualities of both. Wherefore milk is coagulated by different methods, according to the purposes for which the cheese and the whey are intended.

As the acid, which discovers itself in the milk when it curdles spontaneously, is more than is sufficient for its coagulation, and as it communicates its taste both to the cheese and to the whey, milk is not generally left to curdle spontaneously, either for the making of cheese for aliment, or of whey for medicine. This sensible acidity is avoided, by mixing with the milk, before it has become too old, the smallest quantity of acid necessary for coagulation, and by accelerating this coagulation by a convenient heat.

The common and also the best method is to dilute, in three or four spoonfuls of water, about 18 grains of rennet for every two pounds of milk, and to mix it with the milk, which is then to be placed upon hot embers. The milk, by means of this rennet, curdles more or less quickly according to the degree of heat given to it. When the curd is intended to be eaten before the whey is separated, the heat ought to be very gentle, and the coagulation slow. If cheese be intended to be made of it, more expedition may be used; and as soon as the milk is curdled, it is to be cut, to allow the whey to separate from it by draining. If this be done for the sake of the whey, more heat may be given, and the separation may be more expeditious. It is then to be passed through a strainer.

The butyraceous, caseous, and serous parts are separated by these operations only imperfectly. Each of these three matters partakes of the other two. The butter and the cheese are purified in the manners mentioned under their particular articles. The whey must be cleared from the caseous particles it contains, and which had not been curdled sufficiently, by throwing in and mixing well with it a liquor made by boiling about 15 grains of cream of tartar in water, and also the white of an egg; after which the whey is to be filtered through brown paper.

The rennet employed to curdle milk is nothing else than a milky matter found in the stomachs of calves. This matter is usually salted that it may be kept. It smells of old cheese, and coagulates milk, because it contains a sufficient but not sensible quantity of acid. It is a kind of leaven, capable of producing the acid fermentation of milk. The same may be laid of several other substances, such as the flowers of almost all thistles, of wall-flower,

hence called curdle-milk, &c. All these matters which do not seem acid, and which do not communicate any sensible acidity to milk, curdle it very well, undoubtedly from the latent acid which they contain. The operation for clarifying whey is necessary, because it could not otherwise be filtered from the caseous particles adhering to it, which must be curdled again, or more strongly by boiling with the cream of tartar and white of an egg. See FILTRATION.

Well clarified whey is very far from being a pure phlegm. It is indeed the most watery part of the milk, but it is also impregnated with all the parts of the milk which are soluble in water. It has accordingly a sensible taste, which becomes very evident, when the whey is evaporated to nearly one half of its quantity. It is saccharine and somewhat saltish. In whey is contained dissolved a considerable quantity of extractive substance of the nature of saccharine juices, and it is accordingly susceptible of the spirituous fermentation. The tartars certainly make from it a spirituous drink, or kind of wine.

Whey contains, besides this saccharine fermentable substance, several kinds of salts which may be obtained by crystallization. If three fourths of clarified whey be evaporated, and the remainder be then set in a cool place, a certain quantity of reddish crystals will be formed. This is the essential salt of milk. It is called the *sugar of milk*, from its taste, which is manifestly saccharine. But this color and taste are extraneous to the salt, and proceed from the extractive matter of the liquor in which the salt was crystallized. Accordingly, if the crystals are well drained, dissolved in pure water, and crystallized, they will be much whiter and less saccharine. By repeating the operation a third or a fourth time, the crystals may be rendered perfectly white and almost tasteless.

This salt is of a singular nature, but is little known, because it has not been well examined. We know only that it is not deliquescent, and requires much water to dissolve it. Mr. Beaumé has promised in his Pharmacy, that he will publish some particulars relative to this subject, which cannot fail of being interesting.

The liquor which furnished these first crystals contains also some more, which may be obtained by continuing the evaporation and crystallization. If the evaporation be still continued after the formation of the second crystals, some common salt will be formed; and lastly the mother-water contains, as Mr. Beaumé affirms in his Pharmacy, some fixed alkali, which consequently is obtained without burning. As this alkali is not sensible either in milk or in whey before the above-mentioned operations, it probably exists in the milk, combined with some matter with which it is saturated, and which is separated from it by these operations. All this requires a further and more particular inquiry.

Milk, and consequently whey, contains no principle more volatile than water, and therefore none of its other principles are lost by exposure to the heat of boiling water. But if we distill in a naked fire the residuum of whey, evaporated in a sand-bath to dryness, as Mr. Geoffroy has done, phlegm will be at first obtained, then a citron-colored acid spirit, and afterwards a thickish oil; lastly, a residuous coal will remain in the retort, which will become moist by exposure to air, from the saline substances with which it is mixed.

What we have said concerning whey, together with the explanations we have given under the articles, BUTTER of MILK, and CHEESE, are sufficient to

to give just notions concerning the nature of milk. The result is, that milk is a mixture, first, of butter, which is an uncombined oleaginous matter, of the nature of fat, and not volatile, sweet oils (*see OIL*); secondly, of cheese, which is a more earthy matter, containing oil combined nearly in a mucilaginous state; and, thirdly, of whey, which is a watery liquor containing several salts, together with a saponaceous substance, or oil combined in the same manner as the oils of saccharine juices.

Milk is much employed in aliments and in medicine. It is softening, in-craftating, cooling, restorative, and healing. It is proper against a sharpness of humors, as tetters, erysipelas, or gout, when these diseases are not accompanied with fever; and against internal suppurations, phthisis, marasmus, and slow fevers. Sick persons are frequently dieted with milk alone, and generally with good effect. But we must observe, that although milk be a food already prepared by nature, and as it were half-digested, it does not agree with all constitutions. It is apt to occasion one of two very opposite disorders, fluxes and costiveness. This is remedied by diluting it with water, or by proper correctives, or by chusing that kind of milk which suits best with the constitution, and the disease to be treated. The milk of goats, for instance, has been observed to suit better than cows milk, with those persons whose constitution disposes them to diarrheas.

Whey is not used as an aliment, because being deprived of the butyraceous and caseous parts of the milk which are alimentary, it is much less nourishing than milk. It affords, nevertheless, a little nourishment by means of the saccharine matter which it contains. Like milk, it is softening and cooling, and may be employed as such in the same diseases, but it is much more diluting, aperitive and laxative. It is frequently used as a vehicle for other remedies.

We are far from having concerning milk all the knowledge which is to be wished. Many inquiries remain yet to be made on this subject. For besides the salt of milk, which is almost only known by name, nobody has hitherto undertaken a chemical examination, and a comparison of the several kinds of milk drawn from different animals, which milks do nevertheless differ considerably from each other, as has been observed in the *Elements of Practical Chemistry*. Considerable differences must also be observable in the milk of the same animal in different circumstances, and particularly with relation to the nature of the food which the animal has eat: for we are certain, that milk partakes much of the nature of the aliment used by that animal which furnishes it. *See* CHEESE.

The milk of nurses is well known to acquire the virtues of drugs taken by them; and thus remedies are frequently applied to children at the breast. (c)

(c) Thus the color of saffron, the bitterness of wormwood, and the smell of garlic, are given to the milk of a woman who eats these plants; and also the purgative and inebriating effects of certain substances are communicated from the nurse to the child.

Hoffman found by experiments, that the milk of cows and of goats contained more of the butyraceous and caseous, and less of the ferrous and of the saccharine particles than human milk, and the milk of asses.

## CCCCLIII. MILK of LIME. MILK of SULPHUR.

The name of milk is given to substances very different from milk properly so called, and which resemble milk only in color. Such is water in which quicklime has been slaked, which acquires a whiteness from the small particles of the lime being suspended in it, and has hence been called the *milk of lime*. See QUICKLIME. Such also is the solution of liver of sulphur, when an acid is mixed with it, by which white particles of sulphur are made to float in the liquor. See LIVER of SULPHUR.

CCCCLIV. MILK of V E G E T A B L E S. For the same reason that milk of animals may be considered as a true animal emulsion, the emulsive liquors of vegetables may be called *vegetable milks*. Accordingly emulsions made with almonds are commonly called *milk of almonds*. But besides this vegetable milk, which is in some measure artificial, many plants and trees contain naturally a large quantity of emulsive or milky juices. Such are lettuce, spurge, fig-tree, and the tree which furnishes the elastic American resin. The milky juices obtained from all these vegetables derive their whiteness from an oily matter, mixed and undissolved in a watery or mucilaginous liquor. Most resinous gums were originally such milky juices, which afterwards become solid by the evaporation of their most fluid and volatile parts.

These natural milky juices have not been examined by any chemist. Such an examination would, however, procure much essential knowledge concerning vegetable economy. We should probably find examples of all kinds of oils reduced into milky juices; and this knowledge cannot fail of throwing much light on the nature of resins and gum-resins. See GUM-RESINS and RESINS.

CCCCLV. MINE S. See ORES.

CCCCLVI. MINIMUM. Minium, or *red lead*, is a calx of lead, of a vivid yellowish red color. This color is said to be given by a slow calcination and reverberation. Nevertheless, the method of making minium is not well known, as it is not made in small quantities in laboratories. All the minium which is in commerce is brought from Holland, where large quantities of it are manufactured.

Minium is employed in painting, and may serve for all the same purposes as the other calxes of lead. See LEAD. (d)

CCCCLVII. M I R A C L E (C H E M I C A L). When a concentrated solution of fixed alkali is mixed with a strong solution of nitre or of sea-salt, with earthy bases, the earth is so copiously precipitated, that a solid mass is formed from the mixture of these two liquors. As this experiment is something wonderful, it has been called by some chemists *miraculum chemicum*. See MAGNESIA.

(c) Minium is generally prepared by exposing lead to a melting heat till it is converted into a greyish calx, which is afterwards ground, and again calcined in an oven or reverberatory furnace, during several days, with a moderate heat. The action of the flame and of air is said to be necessary to produce the red color. For which reason, the matter to be calcined is frequently stirred during the operation, that its surface may

be changed, and thus the whole of it exposed to air and flame. Three parts of lead are said to produce nearly four parts of minium; but if the minium be revived, about  $\frac{1}{2}$ th parts only of the lead originally employed, will be recovered. A smaller quantity of the lead will be recovered by reduction of the minium, if the calcination has been performed more effectually.

CCCCLVIII.

CCCCLVIII. M I X T I O N. Stahl and all his school use this expression to signify the union of the first principles in the most simple compounds. Instead of it, we substitute the terms *combination* and *composition*; which see.

CCCCLIX. M O L Y B D E N A. (e)

CCCCLX. M O R T A R. A mortar is a chemical instrument, very useful for the division of bodies, partly by percussion, and partly by grinding. Mortars have the form of an inverted bell. The matter intended to be pounded is to be put into them, and there it is to be struck and bruised by a long instrument called a *pestle*. The motion given to the pestle ought to vary according to the nature of the substances to be pounded. Those which are easily broken, or which are apt to fly out of the mortar, or which are hardened by the stroke of the pestle, require that this instrument should be moved circularly rather by grinding, or bruising, than by striking. Those substances which are softened by the heat occasioned by rubbing and percussion, require to be pounded very slowly. Lastly, those which are very hard, and which are not capable of being softened, are easily pounded by repeated strokes of the pestle. They require no bruising but when they are brought to a certain degree of fineness. But these things are better learnt by habit and practice than by any directions.

As mortars are instruments which are constantly used in chemistry, they ought to be kept of all sizes and materials; as of marble, copper, glass, iron, griststone, and agate. The nature of the substance to be pounded determines the choice of the kind of mortar. The hardness and dissolving power of that substance are particularly to be attended to. As copper is a soft metal, soluble by almost all menstrooms, and hurtful to health, good artists have sometime ago proscribed the use of this metal. See DIVISION of BODIES.

One of the principal inconveniences of pulverisation in a mortar proceeds from the fine powder which rises abundantly from some substances during the operation. If these substances be precious, the loss will be considerable; and if they be

(e) MOLYBDENA, or *Black lead*, is a blackish friable substance, unsoluble by acids, capable of resisting the most intense heats in close vessels. It has been generally considered as a stony substance, and as being apyrous: but from some late experiments made by Mr. Quist, this substance appears to be decomposed by a calcining heat in open vessels, and even to be almost entirely dissipated or consumed: and, long before these experiments, Dr. Lawson, in his Dissertation De Nihilo, had shewn that blue inflammable flowers were raised from black lead by a violent fire. Mr. Quist relates, that having exposed several specimens of this mineral to a strong heat on a scorifying dish under a muffle, they emitted sulphureous fumes and flowers; that from one specimen, one fifth part only of the original weight remained after calcination; and from an-

other specimen, only a twentieth part remained, of a yellow or brown calx, which being treated with inflammable fluxes, yielded seven-tenths of its weight of a metallic regulus, which appeared to consist of iron and tin. Mr. Cronstedt has accordingly classed black lead amongst sulphureous substances, and calls it *sulphur saturated with iron and tin*.

Black lead is easily dissolved or mixed with melted sulphur; and with this mixture some pencils are made much inferior to those which are made with slips of pure black-lead. Crucibles and portable furnaces are made of black-lead mixed with clay. Black lead is also used to lessen the friction of machines, which it does from the fineness, the want of tenacity, and a kind of unctuousity of its particles.

injurious to health, they may hurt the operator. These inconveniences may be remedied, either by covering the mortar with a skin, in the middle of which is a hole, through which the pestle passes; or by moistening the matter with a little water, when this addition does not injure it; or, lastly, by covering the mouth and nose of the operator with a fine cloth, to exclude this powder. Some substances, as corrosive sublimate, arsenic, calxes of lead, cantharides, euphorbium, &c. are so noxious, that all these precautions ought to be used, particularly when a large quantity of them is pounded.

Large mortars ought to be fixed upon a block of wood, so high, that the mortar shall be level with the middle of the operator. When the pestle is large and heavy, it ought to be suspended by a cord or chain fixed to a moveable pole, placed horizontally above the mortar: this pole considerably relieves the operator, because its elasticity assists the raising of the pestle.

CCCCI.XI. M O T H E R - W A T E R. *See WATER.*

CCCCI.XII. M U C I L A G E. Mucilage is a white, transparent substance, which has little or no taste or smell, the consistence of which is thick, ropery, tenacious, and viscid, when it is united to a certain quantity of superabundant water. It is entirely and intimately soluble in water; and it does not appear to contain any disengaged acid or alkali.

When mucilage is dissolved in a large quantity of water, it does not sensibly alter the fluidity of this liquor; but this water, by evaporation, grows more and more thick, and, lastly, acquires the viscous consistence of vegetable glue.

While the evaporation continues, the liquor becomes more and more thick, without losing any transparency; and this evaporation may be continued till the mucilage becomes quite solid: it then does not differ from gums. If this evaporation or drying has been made with a heat not exceeding that of boiling water, this mucilage, thus rendered solid, and become a gum, may be entirely dissolved again in water, and may again form a liquid mucilage, as before.

Gums or solid mucilages, when well dried and very hard, being exposed to an open fire, are not liquefied as resinous matters are; they swell, and emit many fumes, which at first are watery, then oily, fuliginous, and acrid.

This matter, at the same time, becomes black, and is then capable of being inflamed; but not before it is thoroughly dried, and almost reduced to the state of coal.

If mucilage or gum be exposed to distillation in close vessels, nothing but water is obtained, with a heat not superior to that of boiling water; and the matter which remains in the retort seems to be nearly of the same degree of dryness as before the operation; which is a certain proof that distillation does only deprive the gum of its superabundant water. If a greater degree of heat be then applied, more aqueous liquor will be obtained, which gradually becomes more and more acid and empyreumatic. By continuing the distillation with a fire gradually augmented, a little thick oil and volatile alkali pass; and, lastly, a considerable quantity of residuous coal remains in the retort, which burns difficultly in open air; together with some ashes, from which a very little fixed alkali may be obtained.

Mucilages and gums are not soluble either by oils, or by spirit of wine; which latter menstruum has the property of taking from these substances the water in  
which



which they are dissolved; so that if spirit of wine be mixed with a liquid mucilage, or with water in which gum is dissolved, this spirit will take all the water of the solution, and will separate the gummy matter in form of an almost dry white precipitate. We may easily perceive that this experiment cannot succeed but by adding a sufficient quantity of spirit of wine, that is, a quantity proportionable to the quantity of water united with the gummy matter.

From what we have said concerning the general properties of the gummy vegetable principle, we may conclude, first, that excepting a portion of superabundant pure water, no substance is contained which is volatile with the heat of boiling water; consequently no volatile saline spirits, no essential oil, or spiritus rectior, at least in any sensible quantity.

Secondly, we may conclude, that this gummy matter is composed, first, of a certain quantity of oil of the nature of sweet oils, which are not volatile, nor soluble in spirit of wine; secondly, of water; thirdly, of vegetable acid; and, lastly, of an attenuated earth; that the oil which is a principle of gums is in small quantity, since they are not attackable by oily or spirituous solvents; and that they are difficultly combustible.

Thirdly, that the portion of oil which is combined in gums is in them so intimately united with a sufficient quantity of acid, that it is rendered entirely soluble in water.

Fourthly, that as all compounds, the principles of which are nearly in these proportions, and in this kind of union, are susceptible of fermentation, all gummy matters are fermentable; they are also nutritive. This is confirmed by experience. Some differences, however, exist in this respect betwixt the several mucous vegetable matters. Some of them, particularly those called *gums*, are very transparent, insipid, little nutritive, and susceptible of only an imperfect fermentation, which passes soon to vapidity or mouldiness: others, namely those which all the farinaceous substances furnish, are less transparent, less insipid, more viscid, more nutritive, and susceptible of a complete spirituous fermentation, particularly when they are placed in circumstances favorable to fermentation. See *BEER*.

Although the existence of mucilage in all vegetables and in all their parts is not equally sensible, we may nevertheless consider it as universally diffused through the vegetable kingdom. Plants, or the parts of plants, from which no mucilage is obtainable by ordinary processes, do all impregnate water with an extractive matter; and this extractive matter includes always a certain quantity of mucilaginous substance, which remains mixed with the saline and saponaceous matters, and which might even be separated by certain processes, particularly by a proper application of spirit of wine.

The use of the mucilaginous matter appears to be in the vegetable kingdom exactly the same as that of the gelatinous matter in the animal kingdom. These two substances, which, in many respects, resemble each other, are both of them singularly nutritive and reparative.

Accordingly, nature has provided all the plants which have occasion for it with plenty of it; and has even produced a superabundant quantity of it for the increase and support of each individual. This superabundance of nutritive matter is reserved with economy in vegetables, as in animals, for the generation and reproduction of individuals of the same species.

The seed and eggs of animals are then nothing else than a provision of gelatinous matter, intended for the production and nutrition of their young. The same observation is applicable to all the seeds and kernels of vegetables, which may be considered as their eggs; all which contain so much mucilage, that it may be easily obtained abundantly from them by infusion or boiling in water.

Some of these, such as the seeds called *emulsive*, furnish easily by infusion in water a considerable quantity of the kind of mucilage which we mentioned above was transparent, not very nourishing or viscid; but they also contain a considerable quantity of sweet oil, which may be obtained by expression alone. The others, those called *farinaceous grains*, being bruised and boiled in water, are almost entirely reduced to a glue, which is nothing else than the kind of mucilage which we mentioned as being very nutritive. These grains do not, like the emulsive seeds, contain an expressible oil; but a considerable quantity of oil enters into the composition of the mucilage. Accordingly, these two kinds of seeds contain the same materials, with this difference, that a large portion of sweet oil is disengaged in the emulsive seeds, and is combined in the farinaceous grains.

The kind of grains called *leguminous*, which are very numerous, contain a meal more mucilaginous than those properly called farinaceous; but they are likewise provided with a greater or less quantity of sapid or even saccharine substance, which also is a kind of mucilage, and of a truly nutritive nature. See SUGAR.

The roots of many plants are filled with much mucilage or saccharine matter. Some of them are farinaceous; especially those which produce the entire plant.

Mucilage is easily obtained from the vegetable substances above-mentioned, by infusing or slightly boiling in water those which contain it most abundantly, as linseed, the seeds of psyllium, of quinces, the roots of marshmallows, &c. The water by this means soon becomes ropery and viscous, like the whites of eggs. The water and heat necessary for this extraction are incapable of causing any alteration upon the mucilages, which are therefore obtained exactly in the same state as in the vegetable itself.

From many trees much mucilage issues spontaneously, which being dried by the air and sun, forms gums. These trees are chiefly the acacia, the almond, the peach, the apricot, the plumb, and even the pear and apple-trees. May not this exudation of nutritive substance, which might be considered as the effect of a superabundant quantity of nutritive juice, rather proceed from a stoppage or too great fulness of the vessels containing it? That this exudation proceeds from a disease in the tree, is rendered probable by this remark, that all the trees from which much gum issues, become languid and dry, and do at length perish, with all the appearances of trees which die from want of nourishment.

Gummy and mucilaginous matters serve for many different purposes. Gums are employed in the arts, in dyeing, in painting with water-colors, and for giving lustre and firmness to stuffs.

Mucilages are the most relaxing, emollient, and softening remedies in medicine. But if we take the term *mucilaginous matter* in its most extensive meaning, and apply it, as we may with propriety, to all the farinaceous and saccharine vegetable substances, then the above-mentioned advantages are nothing  
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in comparison of their infinite utility to us, since that substance constitutes the chief and sole matter of our nourishment, whether we obtain it directly from the grains and roots of vegetables which we eat, or that it has previously served as food to the animals which we use as food.

CCCCLXIII. M U F F L E. See VESSELS (CHEMICAL).

CCCCLXIV. M U S K. (f)

CCCCLXV. M U S T. By *must* is meant the saccharine juice of several fruits susceptible of the spirituous fermentation, and particularly of grapes, before the commencement of this fermentation. Accordingly, *must* is, properly speaking, what is commonly called *sweet wine*. See JUICES (SACCHARINE) and WINE.

CCCCLXVI. M Y R R H. (g)

(f) Musk is an animal juice, the most odoriferous of all known substances. Its smell is very diffusive, and adheres very tenaciously to substances perfumed with it. From thirty grains, water extracted twelve grains, and from the same quantity, spirit of wine extracted ten grains. Spirit of nitre and oil of vitriol totally dissolve it. The former destroys the whole of its smell, and the latter the greatest part of it. Spirit of salt, dilute spirit of vitriol, and vinegar, have no effect upon it. Spirit of sal ammoniac dissolves a little of it. Oil of tartar scarcely acquires any tinge from musk, but extricates from it a volatile urinous smell. Musk is not soluble in oils expressed or distilled. By distillation in a retort, musk yielded the animal principles, empyreumatic oil, volatile spirit and salt. Musk is used medicinally, and as a perfume. In the distillation of odoriferous waters and spirit, a small portion of musk included in a linen cloth, is generally hung in a still-head, the vapors of both liquors extracting its scent. Spirit distilled with musk immersed in it acquires little of its smell. But water by this method acquires both the smell and taste. A minute portion of musk greatly improves the fra-

grance of the distilled odoriferous waters, as those of lavender and rosemary, and heightens the smell of other odoriferous ingredients, without communicating any of its own peculiar smell. *Neuman*.

(g) MYRRH is a gum resin, from sixteen ounces of which twelve ounces and a half were extracted by water, and from the same quantity five ounces were extracted by spirit of wine. The whole smell and taste of the myrrh is received either by the water, or by the spirit, and the residuous substances are perfectly insipid. By evaporating the aqueous infusion, an extract is obtained, containing all the bitterness, but not the flavor of the myrrh, which seems to reside in an essential oil; three drams of which may be obtained by distillation of a pound of myrrh. If some powdered myrrh be inclosed in the white of a hard boiled egg, and set in a moist cellar, the liquor into which the egg will be gradually resolved, will extract nearly all the smell and taste of the myrrh. This liquor, which is commonly called, *oil of myrrh per deliquium*, may be precipitated and coagulated by spirit of wine. This coagulum is soluble by water.

## N.

CCCCLXVII. **N A P H T H A.** This name is given to the petroleum which is the most white, volatile, and thin, whether this bituminous matter possess these qualities naturally, or has acquired them by rectification. *See* PETROLEUM and BITUMENS. (b)

CCCCLXVIII. **N A T R U M** or **N A T R O N.** This is a native alkaline salt of the nature of the mineral or marine alkali, which is found crystallized in Egypt, and in some other hot countries, in sands which surround lakes of salt water. This crystallization is produced by the spontaneous evaporation of this water; and as that water contains other salts also, besides the mineral alkali, the natrum is not a pure mineral alkali, and is naturally found mixed with other saline matters, and particularly with common salt. This salt is said to be the nitre of the ancients. It is little known in this country. The soda, and salt obtained from it, being of the same nature as the natrum, supply all our purposes. *See* ALKALI (MINERAL).

CCCCLXIX. **N E P H R I T I C S T O N E.** (i)

CCCCLXX. **N E P H R I T I C W O O D.** (k)

(b) Mr. Pucelle thinks that naphtha is formed by a distillation of bitumens occasioned by subterranean fires.

(i) **N E P H R I T I C S T O N E.** This is a green, semi-transparent, foliated stone, unctuous to the touch, not compact, nor capable of being polished. By Wallerius it is ranked amongst gypsums; and by Pott, amongst calcareous earths. Some other authors more justly consider it as a steatites, from its unctuousity, from its partial solubility in acids, and from its property of becoming hard by burning. Its green color is occasioned by copper, a small

quantity of which metal Mr. Pott extracted from this stone, by fusion with borax. Neuman affirms, that by distilling the stone, he obtained a small portion of an empyreumatic oil, and of an ammoniacal salt.

(k) **N E P H R I T I C W O O D.** This wood gives a blue color to spirit of wine, or to water. This color is changed to a yellow by acids, and afterwards restored to a blue by alkalis. Dr. Lewis observes, that it is the only woody matter which gives a blue tincture; and that this is the only vegetable blue which is thus destructible by acids.

CCCCLXXI.

## CCCCCLXXI. N I C K E L. (1)

CCCCCLXXII. N I T R E, or SALTPETRE. Nitre is a neutral salt composed of a peculiar acid, called *nitrous acid*, saturated with fixed vegetable alkali.

This salt has a saline and cooling taste, which is succeeded by another more disagreeable taste. It is easily soluble in water, but in much greater quantity in boiling than in cold water. It is consequently one of those salts which are more readily crystallized by cold than by evaporation. Therefore, if fine crystals of nitre are required, this salt must be dissolved in water, and heat must be applied, that the water may take up more salt than it can retain when it is cold. When this solution of nitre is allowed to cool, many crystals will be formed which will be so much larger and finer, as the quantity of salt operated upon at the same time has been greater, and as the cooling of the liquor has been slower.

Crystals of nitre are oblong solids, the large faces of which are parallel. They are kinds of prisms furrowed by parallel and longitudinal grooves.

The acid and alkali, of which nitre consists, are united together so intimately, that it may be considered as a perfect neutral salt. It is not deliquescent, but it retains strongly the water of its crystallization, by which its transparency is preserved even in a dry air, and it does not effloresce, or become mealy.

Nitre is one of the most fusible salts. It is liquefied by a heat much less than what is necessary to make it red, and remains thus in tranquil fusion without swelling. If nitre thus melted be left to cool and fix, whether it has been made red-hot or not in this fusion, it coagulates into a solid, sonorous, semi-transparent mass, and is then called *mineral crystal*. This melted nitre, or mineral crystal, has, excepting the arrangement of the crystallization, all the same properties as crystallized nitre. Mr. Beaumé observes, that nitre loses by fusion little, if any, of the water of its crystallization, since the weight of the mineral crystal is nearly the same as the weight of the nitre employed.

(1) NICKEL is a semi-metal, first described by Mr. Cronstedt, in the Swedish Memoirs for the years 1751 and 1754. The properties there attributed to it are, 1. That it is of a white color, inclining to red. 2. Its texture is solid, and shining in its fractures. 3. Its specific gravity is to that of water as 8500 to 1000. 4. It is considerably fixed in the fire. 5. It is calcinable, and its calx is green. 6. This calx is not very fusible, but it nevertheless tinges glass of a transparent reddish brown, or jacinth color. 7. It dissolves in aqua fortis, aqua regia, and marine acid, but difficultly in vitriolic acid. All these solutions have a deep-green color. The vitriol formed of it is also of the same color; and the colcothar of this vitriol, and also the precipitates from the solutions, are rendered by calcination of a light

green color. 8. These precipitates are soluble by spirit of sal ammoniac, and the solution has a blue color. But no copper can be produced by a reduction of the precipitates. 9. It strongly attracts sulphur. 10. It unites with all metallic substances, excepting silver, quicksilver, and zinc. Its attraction to regulus of cobalt is the strongest, next to which is that to iron, and then to arsenic. 11. It retains its phlogiston a long time in the fire, and its calx is reducible by a very small quantity of inflammable matter. It requires, however, a strong red heat before it can be fused, and melts a little sooner, or as soon as, gold or copper. Nickel is contained in the reddish-yellow mineral, called *Kupfer-nickel*, which, besides nickel, contains also iron, regulus of cobalt, arsenic, and sulphur.

Hence the liquefaction of the nitre, even at first, ought not to be attributed to the water of its crystallization, as is the case with Glauber's salt and many other salts, but is a true fusion from the beginning; and this fusibility of nitre is caused by the water which enters into its composition as a salt, and not merely as a crystallized salt. Accordingly, mineral crystal is as fusible as nitre itself. The fusibility of nitre may also probably depend considerably on the inflammable principle which enters its composition, and particularly the composition of its acid. *See ACID (NITROUS).*

When nitre is kept in fusion with a moderate heat, while at the same time it does not touch any inflammable matter, nor even flame, it remains in that state without suffering any very sensible alteration. But if it be kept in a strong fire, it becomes more and more alkalised, because then the flame or burnt phlogiston penetrates it, even through the crucible, sufficiently to destroy the acid of the salt. *See ACID (NITROUS), and DETONATION of NITRE.*

From this property of being alkalised by a strong heat alone, it assists the fusion and vitrification of flints and sands as pure alkalis do. A considerable part, nevertheless, of the nitrous acid may possibly remain in the vitrified substances, or may even contribute to the fusion. *See VITRIFICATION.*

All these substances, which contain phlogiston fixed in a certain degree, and which are nevertheless combustible, being made red-hot and applied to nitre, accelerate greatly the alkalisation of this salt, and render it complete, if these substances be in sufficient quantity; and reciprocally, nitre accelerates much and compleats the calcination or combustion of these substances, because its acid assists the burning of their phlogiston, and burns itself along with this inflammable principle.

This alkalisation is made with or without any sensible detonation, according to the state, the quantity, and the greater or less intimacy of the mixture of the inflammable matters. And the nitre thus decomposed or alkalised is frequently called *nitre fixed* by such or such substance; for instance, *nitre fixed by tartar*; *nitre fixed by coals*. when it is alkalised by tartar or by coals. This name of *fixed nitre* is improper: for when the operation is finished, the residuum contains nothing nitrous, but only the alkali of nitre, with the ashes or earth of the inflammable matter employed for this alkalisation.

The phenomena which nitre exhibits, when it is decomposed by means of phlogiston, are numerous and interesting. The detail and explanation of them may be found under the article *DETONATION of NITRE.*

Nitre is capable of being decomposed by several other substances. These are, pure vitriolic acid; vitriolic acid engaged with an earthy or metallic base; sedative salt; arsenic; and phosphoric acid. But none of these substances acts upon nitre in the same manner as phlogiston does. They do not, like phlogiston, destroy its acid, but only disengage and separate it from its alkali. Hence it follows, 1. That after the decomposition of nitre by means of these saline substances, its alkali does not remain alone, but a combination of this alkali with the substance employed for the decomposition. 2. If we make the operation in vessels proper for distillation, the nitrous acid which has been separated during the operation from its alkali may be obtained. For the detail of these operations see the words, *SPIRIT of NITRE, SALT (NEUTRAL ARSENICAL), SALT (SEDATIVE), and PHOSPHORUS.*

Nature furnishes us with a very small quantity of nitre ready formed, in comparison of the quantities which are employed. Nitre is found naturally crystallised in India, and as it is swept from earths or stones with brooms, it is called the *sweepings of nitre* or of *saltpetre*. A nitre may be obtained from several plants. These are the two kinds of natural nitre. All other nitre is only begun by nature, and is found in the walls of old buildings. Art is required to complete it, to extract it, and to purify it, as we shall proceed to explain, after having made some reflexions on the generation of this salt.

As neither nitre nor nitrous acid, engaged in any base whatever, is any where found collected from time immemorial in great quantities, as the vitriolic and marine acids are, but is only found produced from time to time in places where not an atom of this salt existed; it evidently appears to be habitually produced by the concurrence of circumstances favorable to its formation.

Some chemists and naturalists believe, that because nitre is commonly obtained from substances long exposed to air, that nitrous acid existed ready formed, like the other two mineral acids, and that it is successively deposited in matters proper for its reception. But this opinion is quite rejected, particularly by chemists, since they have been assured from experience, that by a long exposure of the most proper substances for the reception and retention of nitrous acid, as fixed alkali, to the air, no nitre is ever obtained. Cloths soaked in fixed alkali, and exposed to air by hanging freely, are indeed at length filled with crystals of a neutral salt; but this is vitriolated tartar, and not nitre.

On the other side, we are certain that nitre or nitrous acid, engaged in any base, is never found but in places capable of being impregnated with vegetable or animal juices. Hence, it is never found in any place inaccessible to these matters, as in very great heights or deeps.

Mr. Lemery the younger considering these things, and that nitrous salts or perfect nitre are obtained by analysing many vegetable and animal matters, has concluded from thence, that this salt exists naturally ready formed in the individuals of these two kingdoms, which are, according to him, the only source of it. In the Memoirs he has given upon this subject, he explains how nitre, or rather nitrous acid, which is either at first not perceptible, or in small quantity, in animals and vegetables, may be afterwards unfolded by the action of the air, and by the fermentation excited in these compound bodies as soon as their life ceases.

But this opinion, although specious, is liable to great difficulties; for vegetables and animals are not permanent beings, but are continually produced and destroyed. The peculiar substances then, of which they are composed, consist of principles extracted from the air and the earth. We may therefore object to Mr. Lemery, that the nitre found in animals and vegetables is extraneous to them, and proceeds originally from the air and the earth.

This objection is supported by a well-known fact, namely, that the most nitrous plants contain very unequal quantities of it, according to the quantity of the nitre which is contained in the soil or earth in which they grow. Besides, vegetable and animal substances may be putrified without affording a larger quantity of nitre, unless it has been exposed to the air and mixed with earthy and stoney matters. Vegetable and animal matters contain the nitre or nitrous acid ready formed, only accidentally; they do not even always contain

tain all the materials necessary for its production: and all that we can infer is, that the concurrence of animal and vegetable matters is necessary for this production of nitre.

The third opinion concerning the origin of nitre is that of Stahl. This chemist, who thought, with Beccher, that the vitriolic is the only original acid, and that from this all other acids are produced, believed that the nitrous acid is only the vitriolic acid metamorphosed by the union it contracts with some other principle. This principle, according to him, is phlogiston: and putrefaction is the method employed by nature to combine this acid with the inflammable matter of putrifying substances, in the convenient proportion and manner for giving to it the specific character of nitrous acid.

This is the most probable opinion of all. For without considering the analogies which are observable betwixt the nitrous and the volatile sulphureous acids, most of the circumstances attending the origin of nitre seem to be further proofs of it.

First, the atmosphere appears to contain the vitriolic acid, or some matter in which it exists, and from which it is deposited in proper bases.

Secondly, nitre is never found but in earths or stones which have been impregnated with vegetable or animal juices, and these juices must have remained a sufficiently long time to have sustained the whole putrefactive process.

Thirdly, Messrs. Mariote and Lemery have exposed to pure air, during a long time, earths and stones very fertile in nitre, after having deprived them of all their contents, and no nitre was formed in them, because they had not again imbibed any vegetable or animal juices.

Lastly, the Academy of Sciences at Berlin, having proposed some years ago, for the subject of their annual prize, to determine the origin and principles of nitre, Dr. Pietchs, who obtained the prize, says in his Dissertation, that having soaked with urine and vitriolic acid a calcareous stone, and having afterwards exposed it to the air during some time, he found it afterwards full of nitre. This experiment is favorable to Stahl's opinion, which Mr. Pietchs adopts in his Memoir.

One part indeed of the observations which we have related agrees also with Mr. Lemery's opinion. But whether nitre be produced in vegetables and animals during their life, as Lemery believes; or whether a part of the principles of these substances combines afterwards with the vitriolic acid diffused in the air, or pre-existing in earths and stones, as Stahl says; this may certainly be inferred, that nitre does not exist ready formed, and in great quantities in nature, as the vitriolic and marine acids are, but that it is generated and produced from time to time by the concurrence of circumstances favorable to its formation.

We may observe upon the subject of the principles and production of the nitrous acid, that as we have shewn that putrefactive matters are requisite to its formation, and as vegetable and animal substances are only susceptible of putrefaction, this acid therefore belongs equally to the three kingdoms of nature.

Nitrous acid is not commonly found disengaged: neither is it generally united with any one particular basis, as marine acid is; but it is no sooner generated, than it combines with any matters which it can dissolve, and which are within



its reach. Accordingly, it is sometimes united with a fixed alkali, and consequently forms ordinary nitre; such are what are called the sweepings of nitre and the nitre of plants; but most frequently it is combined with absorbent earths, because it generally meets these in places where it is formed most copiously: it is, therefore, most generally found in the form of nitre with an earthy basis.

The most favorable places for the production of nitre are the habitations of men and animals, and particularly such as are low and moist, as cellars, kitchens, stables, houses of office, and others of that kind, which are apt to be impregnated with vegetable and animal matters, and also to have an habitual moisture, which is favorable to putrefaction; and, lastly, which are sheltered from rain, which might otherwise dissolve and carry off the nitre as soon as it is formed.

These buildings are true nitre-beds. When they are old, their rubbish and plaster are full of nitre: but this nitre is only a nitre with an earthy basis, which is not susceptible of crystallization or detonation, which are the two essential qualities in nitre for the principal uses to which it is applicable, and which it cannot possess but by being joined to a basis of fixed alkali. Besides, the nitre of rubbish is mixed with much common salt, which comes also from the vegetable and animal matters, and from some heterogeneous substances, which alter its purity. The chief intention, therefore, of the operation upon rubbish, to obtain a perfect nitre, is to furnish this salt with a basis of fixed alkali, and to disengage it from the heterogeneous matters which alter its purity. These views are accomplished in the following manner.

The rubbish containing nitre is to be broken to small pieces, and mixed with nearly an equal quantity of wood-ashes. This mixture is to be put into casks ranged along each other, placed vertically on one of their ends, and supported at the height of two feet above the ground. At the bottom of each cask is a hole, filled with straw. Water is to be poured into the first cask; and this water, when impregnated with all the saline matter in the mixture, flows into a bucket placed under the cask for its reception. This same water is poured successively into the other casks, and thus becomes impregnated with more and more saline matter. The makers of salt-petre observe always to pass the strongest lixiviums through casks filled with new matter; and before they throw away the matter of a cask when almost exhausted, they pass through it the first water yet unimpregnated. By these operations, which are well contrived, they obtain a lixivium as much impregnated as it can be, and they at length entirely exhaust the rubbish of all the nitre it contained.

The lixivium of nitre thus prepared is carried to great copper cauldrons, in which it is boiled and evaporated, till it is sufficiently strong for the crystallization of the salts. As the two crystallizable salts contained in this lixivium are nitre and common salt, and as the latter of these salts is crystallizable by evaporation only, and the second by cold only; the common salt crystallizes first during the evaporation, and forms small cubical crystals which subside to the bottom of the cauldron. The salt-petre-makers call it the *grain*. They take it out with large ladles, and put it in a basket hung over the cauldron to drain. This evaporation is continued, and the grain is to be taken away as fast as it is formed, till the liquor be so much evaporated, that, when it is cold, much nitre will

will be crystallized in it; and in order to discover when it is sufficiently evaporated for that purpose, a small quantity of it is to be taken out from time to time. When they perceive, upon cooling the liquor, that a sufficient quantity of nitre is formed in it, they remove the liquor from the cauldron into large copper basons, which they carry to a place designed for the crystallization.

As this liquor contains much nitre, and as it is quickly cooled, the greatest part of the salt is coagulated at the bottom of the basons in unshapely masses, composed of many small needle-like crystals of nitre, and sometimes of large regular crystals upon their surfaces. These are called *sticks of nitre*.

In the basons remains a large quantity of liquor, the nitre contained in which cannot be crystallized but by a second evaporation, which is therefore performed in the same manner as at first, and more nitre is obtained. This operation is repeated till no more nitre can be formed by cooling the evaporated liquor, which then becomes very red and acrid, and is called the *mother-water of nitre*.

This mother-water is composed almost entirely of nitre and common salt with earthy bases, which certainly proceed from too small a quantity of ashes having been mixed with the lixivium of the nitrous rubbish. This mother-water may therefore be avoided, by mixing a sufficient quantity of ashes with the nitrous rubbish, to decompose all the salts with earthy bases which it contains; and thus, after the several evaporations and crystallizations, nothing would remain but a small quantity of red liquor impregnated with unctuous matter.

When only the usual quantity of ashes is employed, the basis of the earthy salts contained in the mother of nitre may be precipitated by adding an alkaline lixivium. This precipitate is white, and is called the *magnesia of nitre*; and, at the same time, the nitre with earthy basis in the mother-water, being changed into a nitre with basis of fixed alkali, is easily obtainable by crystallization: but the salt-petre-makers do not employ any of these methods with their mother-water, which they throw upon the nitrous rubbish after it has been exhausted of its salt by lixiviation. Some time afterwards, they lixiviate this rubbish in the same manner as they did at first, that is, with the addition of ashes, and obtain from it more nitre. We may easily perceive that this operation is precisely upon the same principles as one of those we have proposed. See the words WATER (MOTHER), NITRE with EARTHY BASIS, SALT (COMMON) with EARTHY BASIS.

The nitre obtained by these crystallizations is red, and soiled by the liquor in which it was dissolved, which has also that color. Further, although common salt does not crystallize by cold alone, yet a certain quantity of it always crystallizes along with the nitre; both because the evaporation continues while the liquor cools, and because the nitre, during its crystallization, always takes with it a portion of common salt.

This nitre, which the manufacturers call *nitre of the first boiling*, is therefore impure, and mixed with common salt, and with salts with earthy bases, by which it is rendered unfit for many of the uses to which nitre is applied, as we shall afterwards see. It is purified by dissolving it in pure water, and by proceeding to a second crystallization by cold; and as in this second crystallization, the proportion of nitre to common salt, and to salts with earthy bases, is infinitely greater than at first, so that when the liquor is at the point of the crystallization of the nitre, it is very far from being so much evaporated that the common

mon salt can crytallize at that time; and therefore the nitre obtained in this second operation is infinitely purer than that of the former. It is also white, and is called by the manufacturers *nitre of the second boiling*. This is the nitre employed by distillers of aqua-fortis, for the ordinary aqua-fortis.

But this nitre is not yet sufficiently pure for the preparation of good gun-powder; and it must therefore be purified by a third boiling or crytallization. This is the purest nitre that is sold, or that is kept in arsenals. It is very beautiful and white: but it is not yet sufficiently pure for certain delicate operations in chemistry, and must therefore undergo a fourth purification. For the understanding of the theory of the operations for the extraction and purification of nitre, *see the article* CRYSTALLIZATION of SALTS.

All nitrous earths and stones which are found, contain also a considerable quantity of common salt. The late Mr. Petit, who has given, in the Memoirs of the Academy of Sciences, a good description of the manufactory of salt-petre, says, that the quantity of common salt contained in the materials is nearly a fourth part of the quantity of nitre. It is even probably more, if we comprehend the common salt with earthy basis contained in the mother water of nitre.

This common salt is deposited in the nitrous earths and stones by the vegetable and animal juices which are necessary to the generation of nitre, all which contain more or less common salt. The existence of this common salt in all nitrous substances has induced some chemists to believe that the marine acid was converted into the nitrous. I have heard that a certain person had the secret of transforming common salt into nitre, and that he had proposed to furnish nitre at a cheap rate. A more particular examination of this matter deserves to be made by chemists.

No use is made in France of the common salt in the manufacturing of salt-petre. The farmers-general oblige the manufacturers to give an exact account of it, and to throw it into the river. The purification of it would be difficult; because, during the making of the salt-petre, a febrifugal salt of Sylvius is formed, by the union of the vegetable alkali of the ashes, with the acid of the marine salt with earthy basis; and because the salt of Sylvius has all the properties of common salt, only that its taste is very disagreeable.

The use of nitre is very extensive in medicine, and in the arts, and in chemistry. Persons who know little of chemistry must be surprized that this salt, so inflammable, should be employed in medicine as a powerful diuretic, sedative, and cooler; which virtues it certainly possesses. It is daily prescribed by the most skillful physicians, from ten or twelve grains to half a dram, in some proper drink. It might be given without danger in a much more considerable quantity; for this salt, which is perfectly neutral, is very mild; but it has been observed to produce its intended effects better when it is given in the above-mentioned quantity only. (m)

(m) Some curious experiments concerning the effects of nitre taken internally are related in *Mr. Alexander's Experimental Essays*. From these it appears, that nitre has a power of almost instantly retarding the velocity of the circulation of the blood, and of

surprisingly diminishing the number of arterial pulsations; and that its effects are much more powerful, when newly dissolved in water, than when it had remained dissolved during some hours. As this difference must have proceeded from the cold, which is produced

Besides the nitrous acid obtained from nitre, which is one of the most powerful agents in chemistry, nitre itself is also used in many chemical operations. Its properties of detonating with bodies containing phlogiston, of accelerating their calcination, and particularly the calcination of the imperfect metals, render it useful for the purification of gold and silver when they are alloyed with other metals. As nitre is quickly and easily alkalisied, it enters into the composition of reducing fluxes, or of simple fluxes, to assist fusion and vitrification. Lastly, by its detonation it may be employed to discover the presence of the inflammable principle in substances.

But the most considerable use and consumption of nitre is in the preparation of gun-powder, of which this salt makes a great part; and for this purpose it must be very pure. See POWDER (GUN), and POWDER (FULMINATING).

CCCCLXXIII. NITRE (ALKALISED.) This is the fixed alkali which remains after the nitrous acid has been destroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*. See NITRE (FIXED).

CCCCLXXIV. NITRE (AMMONIACAL). This is a neutral salt resulting from the combination of the nitrous acid, to the point of saturation, with volatile alkali. See AMMONIACAL (NITROUS) SALT.

CCCCLXXV. NITRE (CALCAREOUS), or NITRE with EARTHY BASIS. Calcareous nitre is a neutral salt compounded of the nitrous acid combined to saturation with a calcareous earth. It is generally called *nitre with an earthy basis*, because the salts formed by the nitrous acid with the other earths have not been attended to.

Nitrous acid dissolves with great activity all calcareous earths and stones, calcined or uncalcined. It dissolves a large quantity of them, and leaves no residuum when they are pure. By this combination is formed a neutral salt very deliquescent. This salt is not susceptible of a true crystallization. It has a poignant, acrid, and bitter taste. If it be evaporated to dryness, it becomes solid, and seems to be an earthy matter, which does not detonate, or at least very weakly, with inflammable matters.

All these properties of nitre with an earthy basis proceed from the weak adhesion of its acid to the earth. This adhesion is so weak, that if the salt be distilled in a retort, an acidulous phlegm will first pass over; and when the fire is encreased, all the acid will follow, excepting a small portion which adheres more strongly, but which may be at last expelled by calcination in an open fire.

Mr. Pott, who has particularly examined the combination of nitrous acid with quicklime, says, that this acid suffered remarkable alterations by distillation from quicklime, and by repeated cohobations. By these experiments he obtained a nitrous salt more sensibly susceptible of crystallization and detonation than ordinary nitre with earthy basis; which is very remarkable, and may induce us to suspect that a part of the nitrous acid, and of its inflammable principle, might combine with the quicklime, so as to give it the character of

duced by nitre during its solution, probably a much greater effect would be produced by procuring that solution in the stomach. A remarkable instance is given in that book of a sudden swelling over the whole body of a woman, and other dangerous symptoms, which were occasioned by her swallowing a solution of nitre in water, by mistake, instead of Glauber's salt.

a fixed

a fixed alkali; or that the nitrous acid, deprived by the quicklime of part of its phlogiston, might be rendered more capable of contracting a strong union with the quicklime. From what Mr. Pott has said in his Dissertation, the nitrous acid seems, by treatment with quicklime, to be rendered susceptible of an entire decomposition. See his Dissertation in the French edition of his works, by Mr. Machy, tom. III. p. 178.

A great quantity of nitre with earthy basis is found ready formed in nitrous earths and stones. Nitre is most frequently produced in that form. This nitre may be decomposed by a fixed alkali, which unites with its acid, and precipitates the earth, in the process for making salt-petre. The mother-waters obtained in these operations contain still a large quantity of this nitre with earthy basis. See the word NITRE in the preceding article.

CCCCCLXXVI. NITRE (CUBIC or QUADRANGULAR). When nitrous acid is saturated with mineral alkali, a neutral salt is formed, susceptible of crystallization and of detonation, and consequently is a kind of nitre. This salt has all the essential properties of nitre with basis of fixed vegetable alkali; but the marine alkali, which is its basis, changes the form of its crystals, which are not channelled prisms, like those of ordinary nitre, but are cubes, or sometimes parallelipedons, with rhomboidal faces. From these forms the salt has been called *quadrangular nitre*.

We may make quadrangular nitre by combining directly the nitrous acid to the point of saturation with the crystals of soda, or by precipitating with this alkali the solutions of earths and metals made by nitrous acid; or by precipitating with common salt the metallic solutions in nitrous acid, which are susceptible of this precipitation; or, lastly, by decomposing common salt by pure nitrous acid in the operation for making the distilled aqua regia. In all these cases the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This salt is not used in medicine, chemistry, or the arts, as it is rather inferior than preferable to ordinary nitre.

CCCCCLXXVII. NITRE FIXED by ARSENIC. This preparation is the alkali of nitre, the acid of which has been expelled in an open fire by means of arsenic, of which, therefore, some portion is retained by the alkali. To make this preparation, some nitre is to be put into a crucible, which is to be placed in a furnace. When the nitre is red, a small spoonfull of white arsenic powdered is to be projected upon it, which causes a great effervescence, and afterwards vapors to ascend; so that these phenomena are similar to those which happen when nitre is detonated. They are, however, different. In the detonation of nitre, the acid is burnt and destroyed; but in this operation the acid is only disengaged from its basis by means of the arsenic which has that property. The ebullition above-mentioned is caused by the powerful action of arsenic upon nitre. The fumes which rise copiously in this operation are a mixture of those of very concentrated nitrous acid with a part of the arsenic which is sublimed by the heat.

Arsenic is thus projected at different times into the crucible, till no more effervescence is perceived, and then the operation is finished. The fumes which rise in this experiment must be very noxious, and therefore it ought always to be done under a chimney which draws well.

As arsenic cannot disengage the nitrous acid but in proportion as it combines with the basis of the nitre, we might expect to find in the crucible, after the operation, the alkali of the nitre perfectly saturated with arsenic. Nevertheless, the remaining matter is very alkaline, very far from the point of saturation, and retains but a little arsenic. The cause of this is, that the contact of the air and the vapor of the coals make most of the arsenic fly off as fast as it combines with the alkali; for when the evaporation is made in close vessels, the alkali of the nitre is neutralised, and entirely saturated with arsenic. *See ARSENIC, and SALT (NEUTRAL ARSENICAL).*

Nitre fixed by arsenic cannot be employed but as an alkali which contains a certain quantity of arsenic, and mixed with a small portion of nitre which may escape the action of the arsenic towards the end of the operation. This alkali may be employed as a flux, as it powerfully assists vitrification, as Mr. Post has done in his experiments mentioned in the *Lithogegnosia*.

**CCCCLXXVIII. NITRE FIXED by COALS.** To make nitre fixed or alkalised by coals, the proper quantity of nitre is to be put into a crucible, which ought to be so large that the nitre shall take up but a small space in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red-hot, a small spoonfull (about a dram or half a dram) of charcoal grossly powdered is to be projected upon it. Instantly a vivid inflammation happens, which continues till all the charcoal is entirely consumed. When this inflammation or detonation ceases, another quantity of charcoal like the former is projected upon it, and is left to be consumed; and thus charcoal is continually to be projected till no more detonation is caused by it.

Then the matter contained in the crucible, which at first is very fluid, becomes afterwards thick and almost solid, because it is then fixed alkali, which is much less fusible than nitre. The fire must be increased sufficiently to make this alkali melt. During this fusion, some small detonations happen from time to time, which are occasioned by a portion of nitre which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preserved from the contact of the coals. When the matter is in good fusion, and no detonation happens upon projecting small bits of coals, we may then know that the nitre is alkalised, and that the operation is finished. We ought to remark upon this subject, that when the smallest possible quantity of nitre undecomposed is intended to be contained, more coal must be added than seems to be necessary for alkalising the quantity of nitre. In this case the alkali is generally phlogisticated, unless it be afterwards calcined a very long time in an open fire.

If, on the contrary, it is intended to be as much dephlogisticated as possible, and incapable of giving or retaining any extraneous taste or smell, and if its perfect purity from undecomposed nitre be not required; then in the preparation less charcoal ought to be used than is necessary for the detonation of the whole quantity of nitre. This remark is also applicable to nitre alkalised by tartar and by all other inflammable matters. *See ALKALI (FIXED VEGETABLE), and DETONATION of NITRE.*

**CCCCCLXXIX. NITRE FIXED by METALS.** All the metallic substances which are susceptible of decomposition being treated in the fire with nitre, alkalis it, and make it detonate more or less sensibly. The most inflammable of these substances, as zinc and iron, make with this salt so luminous and so brilliant a detonation, that they are advantageously employed for that purpose in fire-works. Other combustible matters are less effectual, but their inflammation with nitre is sufficiently strong to produce all the essential effects of the detonation of nitre; so that after this inflammation, the acid of the salt is destroyed and burnt with the phlogiston of these metals, and its alkali only remains mixed with the earth of the calcined metals. We may then say, that nitre is fixed by metals, as well as we say that it is fixed by coals or by tartar.

After the detonation of nitre with metals, its alkali may be easily obtained alone, and separated from the metallic earths, by lixiviating with water the remainder. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry state. It is essentially the same as nitre alkalised by any other inflammable matter, only that it is much more acrid and caustic, and resembles those alkalis which have been treated with quicklime.

In some known operations of chemistry we may observe this causticity which the alkali of nitre acquires after detonation with metallic matters. Such are the operations for diaphoretic antimony, and for the tincture of metals, or *illy of Paracelsus*, in which the alkalised nitre is rendered exceedingly caustic by the metallic calxes. As, on the other side, volatile alkali treated with these metallic earths becomes always *fluor*, in the same manner as when treated with quicklime, we may conclude that metallic calxes act in general upon alkalis as quicklime does. See the articles of the several metals, and of ALKALI (FIXED), and DETONATION of NITRE.

**CCCCCLXXX. NITRE FIXED by TARTAR.** This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only grossly powdered. This mixture is to be put into an open vessel of unvarnished earthen-ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at first weakly: but as the matter first inflamed kindles the rest, the detonation encreases, a thick fume rises, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the vessel if this be not sufficiently large: then the detonation gradually diminishes, and at last ceases. The residuum consists of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, subject to contain a considerable quantity of nitre undecomposed, and of inflammable matter not burnt, particularly when a small quantity only is prepared at once: but it may be completely alkalised by a proper calcination, and by treating them like other fixed alkalis. See ALKALI (FIXED VEGETABLE).

Nitre fixed by tartar is also called *white flux*, because the most frequent use of this alkali is to facilitate the fusion of ores and metallic matters in essays and

similar operations, for which purposes it need not be perfectly pure. See FLUX (WHITE), and DETONATION of NITRE.

CCCCLXXXI. NITRES (METALLIC), or NITRES with METALLIC BASES. Thus may be named all neutral salts composed of the nitrous acid united with a metallic substance; and the several kinds of these nitres may be distinguished by saying, nitre of silver, nitre of lead, of mercury, &c. See SALTS.

The nitrous acid acts in general powerfully upon all metallic substances, but with remarkable differences, depending on the peculiar natures of the metals.

Some metals, as gold and platina, cannot be dissolved in their state of aggregation by nitrous acid alone, and require the concurrence of marine acid. Others, as tin and regulus of antimony, are attacked so powerfully, and are so well dephlogisticated by nitrous acid, that, as soon as they are dissolved, they are reduced into a white calx, which separates from the acid, and cannot remain united, because they want phlogiston. The marine acid combined with nitrous acid moderates much the action of the latter acid on these metals, prevents their calcination, preserves a part of their phlogiston, and thus is an intermediate substance by which they remain united with the nitrous acid.

Other metals, such as copper and iron, are easily soluble by nitrous acid alone, and remain united when the acid is in much larger quantity than is necessary to dissolve the metal: but when the acid is saturated, a part of these metals always precipitates in state of calx, and the part which remains united with the acid forms an imperfect neutral salt, very deliquescent, and not, or very little crystallizable.

Lastly, the other metals, particularly those called *white* or *lunar*, such as silver, lead, mercury, bismuth, and even regulus of arsenic, are very soluble in nitrous acid, which they saturate, from which they do not precipitate without addition, but form with it complete neutral salts susceptible of crystallization.

Nitrous acid adheres so strongly to these metals, that the metallic salts formed by them are susceptible of detonation, but not sufficiently to resist the action of fire, which expels it without the help of any intermediate substance.

The nitre of silver is known by the name of lunar crystals. See CRYSTALS (LUNAR). Mercurial nitre is also frequently called *crystals of mercury*. This salt resembles much the nitre of silver by its principal properties. See MERCURY. The nitre of lead has this peculiarity, that by exposure to fire without addition of inflammable matter, it decrepitates strongly, and even inflames and detonates. This phenomenon must be attributed to the phlogiston of the lead which is the basis of this salt. Much danger therefore attends the exposure of nitre of lead to fire in close vessels. Probably the nitre of bismuth, and that of regulus of arsenic, would exhibit the same phenomenon, as the phlogiston of these two semimetals is as inflammable as that of lead.



## CCCCCLXXXII. N U T M E G. (n)

(n) NUTMEGS. This fruit contains two kinds of oils, namely, a gross sebaceous oil, and a volatile essential fluid oil; in which last the peculiar taste and smell of nutmegs reside. The essential oil also appears to be of two kinds; one of which is so light, as to swim upon water, and to rise in distillation with spirit of wine; and the other is so gross and ponderous, that it sinks in water, and is with difficulty capable of being distilled with water, and not at all with spirit of wine. Sixteen ounces of nutmegs yielded, by distillation, half an ounce of essential oil, and afterwards four or five ounces of the gross sebaceous oil were found floating on the surface of the water in the still. Rectified spirit of wine dissolves all the essential oil, and a part of the expressible oil. From four ounces of nutmegs nine drams of a concrete oil were expressed. This oil contains a considerable portion of the essential oil. It is brought from India, in form of cakes, and is called *oil of mace*, the mace being one of the exterior coverings of the nutmeg, and containing similar oils. *Neuman.*

CCCCCLXXXIII.

O.

CCCCCLXXXIII. **O**CHRE. (o).

CCCCCLXXXIV. **O**CULUS MUNDI. (p).

CCCCCLXXXV. OFFA ALBA. (q).

CCCCCLXXXVI. **O**IL. Oil may in general be defined a compound body, little, if at all, soluble in water, which is capable of burning with a flame accompanied with smoke and soot, and of leaving a residuum of coal after its distillation.

All oils are composed of phlogiston, acid, water, and earth; for all these principles are discovered in the decomposition of any oil, as we shall soon see.

(o) **OCHRE**. Ochres are ferruginous earths, or calxes of various colors, red, yellow, brown. They seem to have been deposited from ferruginous or vitriolic waters, nearly in the same manner as a reddish or yellowish powder is precipitated from solutions of iron in vitriolic acid merely by exposure to air. By reduction with charcoal or other inflammable matter a considerable quantity of iron may be extracted from these earths. Wallerius says, that the iron thus obtained from ochres is of the kind called *red-short*, that is, brittle when hot. Ochres are used as pigments. By calcination, they all acquire a red color. See **ORES of IRON**.

(p) **OCULUS MUNDI** is a variety of the opal. See **OPAL**. It is opaque, and its color is generally yellowish. It has this peculiar property, that by lying some hours in water, it becomes transparent, and of a yellow amber color. Some are said to acquire by this means a luminous flame color.

(q) **OFFA ALBA**, or **OFFA HELMONTII**. When rectified spirit of wine is added to a solution of mild volatile alkali in water, the spirit having a stronger disposition than the alkali to unite with the water, and having no disposition to unite with the alkali, precipitates the alkali from the water. The alkali thus precipitated, being mild, or combined with fixable air, acquires a solid or concrete state, and is not different from the common mild concrete volatile alkali. It is called the *offa alba*, or *offa Helmontii*. No such precipitation is effected by adding rectified spirit of wine to the caustic volatile alkaline spirit made with quicklime, because the disposition which caustic volatile alkali has to unite with water is so much stronger than that of mild volatile alkali, that the former cannot be ever obtained in a concrete state. See **ALKALI (VOLATILE)**.

But perhaps the water and earth which are in oils are in them combined together, and exist in the state of an acid.

From what we have said concerning the nature of oil, this substance appears to consist of several principles (*r*). It is also one of the proximate principles of all vegetables and animals. The oil in these substances even constitutes the essential distinction betwixt them and those of the mineral kingdom, for in no mineral can the smallest particle of oil be shewn. *See KINGDOMS.*

All the oil obtained from vegetable and animal substances has a certain number of general properties which form its character as oil; but is also much diversified by many peculiar properties, according to the particular kinds of vegetable and animal matters from which it is extracted. Hence, the several kinds of oils are distinguishable from each other. In the present article we shall only mention the most general properties of oil.

All oils in general are volatile, that is, they may by a certain heat be raised into vapors. The heat necessary to evaporate the least volatile oils is not even very considerable. It is much less than a red heat; accordingly oil may be considered as a volatile body.

All oils which are exposed to a heat capable of evaporating them, are easily inflammable, in open air, by contact of any inflamed matter, and burn with a white, luminous flame, accompanied with smoke. Oils, like all other combustible bodies, are entirely decomposed by their inflammation. This inflammability of oil shews that phlogiston is one of its principles.

The inflammable property of oil has misled the ancient chemists down to the time of Becher and Stahl. They gave the name of *oil* to the inflammable principle of metals, of sulphur, and of charcoal, as well as to what is properly called oil. But the inflammable principle which enters into the composition of these bodies is only one of the constituent parts of oil; and oil cannot transfer this principle to any other body without being previously decomposed, and ceasing to be oil. *See PHLOGISTON.*

If any oil be distilled without an intermediate substance, at first a little acid phlegm arises, and afterwards the oil itself; and when a greater degree of heat than that of boiling water has been necessary to raise it, it always acquires an empyreumatic quality, so much stronger as the heat requisite to be employed was greater. This oil is always accompanied with an acid, which becomes more and more strong as the distillation advances. In the retort a small quantity of fixed and residuous coal remains. This coal, and also the foot of oil, are very difficultly combustible; but at length their whole inflammable principle may be burnt: then nothing remains but ashes, which, when well washed from any vestige of fixed alkali which they may contain, are a pure earth.

If the oil in the receiver be examined, we shall find that it is less in quantity than the oil originally employed; from which we may know that a quantity of oil has been decomposed by the operation. The water, acid, and earth, evidently proceed from the decomposed portion of oil. Hence all oil contains

(*r*) Besides the principles or constituent parts of oil, mentioned in the text, we may add, that oils when decomposed by heat, or by mineral acids, emit a very large quantity of elastic vapor, or a kind of fixable air.

the principles mentioned in the definition. This is further ascertained by redistilling the same oil, by which another portion of it is decomposed, and the same principles are obtained. By repeating the operation a number of times, the whole oil may thus be decomposed into water, acid, earth. The phlogiston of the decomposed oil is dissipated in insensible vapors, which cannot be confined and collected, excepting that portion of it which remains fixed in the residuous coal.

An important remark may be made on these repeated distillations of oils, which is, that the undecomposed portion of oil which passes over into the receiver, becomes by each distillation more and more thin and volatile. But as oils chiefly differ from each other in greater or less fluidity and volatility, by repeated distillations, therefore, these differences are lessened, and all oils are approximated to a common state.

These experiments have not been prosecuted so far, as to enable us to determine the possibility of reducing all oils to one and the same state; but every thing inclines us to believe that possibility: and in this case we must conclude, that oil in its greatest purity and simplicity, and which might be called the *oily principle*, is essentially and identically the same in all vegetable and animal matters; and that the differences, although very numerous and considerable, betwixt the several kinds of oils, proceed only from the extraneous matters combined with them, by the mixture of which their essential properties are more or less altered, or disguised.

- We have further another very important consideration upon this subject, to which we ought to attend, and which seems to counteract the opinion we have now explained. This is, that the greater thinness and volatility which oils have, either naturally, or by repeated distillations, the less soot they form when burnt, the less residuous coal they leave, and the stronger disposition they acquire to mingle together, or to dissolve in water; so that by continuing this attenuation of oils, they might probably be brought to the state of ether, and perhaps to that of ardent spirits, which certainly is essentially different from that of oils. Hence we learn, that by repeated distillations, oils are not only purified and rendered simpler, but are also essentially altered and changed.

All oils are also capable of alteration by the action of air, and by the concurrence of other circumstances which favor fermentation. The thinnest and most volatile part of them is dissipated; hence they become thick, and less volatile; and also the acid combined in oils thus exposed is more and more unfolded, and disengaged.

Acids have in general a power of acting upon oils. But the effects produced by their combination with them are very various, according to the nature of the acid, to its degree of concentration, and to the kind of oil.

Mineral acids, even the strongest, act in general but very weakly or not sensibly upon oils, when they are diluted in a large quantity of water; because this water with which they are more than saturated, and with which they have a strong affinity, prevents their acting efficaciously upon the water and phlogiston which are principles of the oil. But when they are concentrated sufficiently, they unite then to the principles of the oil, with a force proportionable to the degree of concentration of the acid, and to the affinity which it has with the inflammable principle, and with water.

Concentrated vitriolic acid attacks powerfully all the principles of oil, occasions an ebullition, considerable heat, and vapors, the smell of which is that of volatile sulphureous acid mixed with empyreuma. By this mixture, the color of the oil is changed to a brown, red, or blackish, and its consistence is rendered very thick.

The action of nitrous acid upon oils is still more vivid, more quick, and remarkable than that of vitriolic acid. From this mixture a more considerable quantity of vapors rise, the effervescence is much stronger, the thickening of the oil is sooner effected, and the heat is so great with most oils, that when the nitrous acid is much concentrated, the mixture becomes red-hot, and is instantly inflamed. *See INFLAMMATION of OILS.*

The action of even the most concentrated marine acid is very different from that of the vitriolic and nitrous acids upon oils; it is much weaker, and we may even say that marine acid does not form any union with oils.

The difference of the effects of these three acids upon oils evidently proceeds from the difference of their affinities with the inflammable principle: for we may observe a similar gradation in the action of these acids upon oils, and upon metallic substances.

As the several kinds of oils have their peculiar characters and properties, they also show considerable diversity in the phenomena exhibited by mixture with acids. We shall find some details on this subject under the several articles of the different kinds of oils. We shall only observe here, in general, that the vitriolic and nitrous acids are disposed to unite very intimately with all oils that are very thin, volatile, and inflammable. But these qualities make them even elude the action of the acids when much concentrated; for during the reaction, they are almost entirely, and sometimes instantly, dissipated in vapors.

The oils which are least thin and volatile, and which are disposed to thicken spontaneously by the evaporation of their most subtle parts (which property they owe to a certain quantity of resinous or gummy matter contained in them), are capable of sustaining all the action of acids, and therefore are the fittest to be inflamed by mixture with concentrated nitrous acid.

Lastly, all oils which have a certain degree of unctuousity and consistence, which are not volatile, nor disposed to thicken by evaporation, resist more the action of acids. They are not altered, nor are half decomposed, like the preceding oils, by acids. They unite with them more slowly and difficultly, and can only be thickened by the united action of the vitriolic and nitrous acids. By being united with these acids, they receive the character of an acid soap, or grease, as we shall see in the article of these oils.

The acids also are altered by combination with oils. We may say in general that acids are rendered weaker and milder by union with oils, and that this union approximates them to the character of vegetable acids, or even entirely assimilates them to these acids: so that if it be true, as we have reason to believe, that vegetables and animals are formed from minerals differently modified, the differences betwixt mineral acids, and the acids of the vegetable and animal kingdoms, must be attributed to the oily principle which the latter acids possess exclusively.

This opinion would be completely proved, if we could sufficiently simplify vegetable acids to reduce them to the quality of mineral acids, and particularly

of the vitriolic, or to transmute perfectly a mineral acid into a vegetable acid. But these important researches have not yet been made, or imperfectly, and not so fully as they deserve.

To transmute a mineral acid into a vegetable by uniting it with the oily principle, this union probably requires to be very intimate, without, however, altering in any measure the constituent parts of the oily matter. For if we employ the vitriolic or nitrous acid so much diluted that it shall not alter the oil with which it is to be united, many obstacles will then occur to prevent its intimate combination, the removal of which obstacles, however, we must acknowledge has not been sufficiently attempted; and on the other side, if acids be employed, so concentrated that they can act easily and effectually upon oils, they will then sensibly alter and half decompose them.

If we try, for instance, to separate by distillation the vitriolic acid from an oil with which it had been combined in its concentrated state, we shall only obtain from thence a very watery and sulphureous vitriolic acid; a certain quantity of empyreumatic and sulphureous oil; a stronger vitriolic acid, but still sulphureous; a thick and bituminous empyreumatic oil; sulphur which will be sublimed to the neck of the retort; and lastly, a fixed and residuous coal, more abundant than would have proceeded from the oil, if it had been distilled alone.

In this experiment we evidently see that a part of the oil is decomposed, that the vitriolic acid is not otherwise changed than by becoming sulphureous, and that it is consequently not approximated to the nature of vegetable acids. See ACID SULPHUREOUS, and SULPHUR.

The great quantity of water mixed with the first portion of acid which rises, is certainly a part of the watery principle of the oil, since the acid employed was concentrated. This acid becomes sulphureous, and forms sulphur, from the union it contracts with a part of the phlogiston of the oil. Lastly, the residuous coal is more considerable in this distillation, because a larger quantity of earthy principle is separated from the other constituent parts of the oil, and particularly from the watery part. The small portion of the vegetable acid obtained in the distillation of oils without addition, does not appear in the present experiment, because it is disguised, or even decomposed, by the vitriolic acid.

I do not know that mixtures of concentrated nitrous acid with oils have been distilled; but probably phenomena similar to those we have mentioned would happen, with those differences only which would be occasioned by the particular properties of that acid.

Of all the experiments hitherto made on the combinations of mineral acids with inflammable matters, those concerning the mixtures of mineral acids with spirit of wine seem to promise most success for the transmutation of these acids into vegetable acids; because the mineral acids are very intimately united with the principles of the spirit of wine; because these acids are necessarily diluted with the water, which is a constituent part of the spirit of wine, and which is in much larger quantity than in oils; and lastly, because the action of acids upon spirit of wine is such, that it entirely approximates that spirit to the nature of oil, altho' the inflammable principle of spirit of wine be not in an oily state, and although all vegetable acids do manifestly contain an oil. Accordingly, if we

we would prosecute this assimilation of mineral acids to vegetable acids, the best method seems to be by treating them with spirit of wine. *See SPIRIT of WINE, ETHER (VITRIOLIC, and NITROUS).*

All oils dissolve sulphur, and form with it a compound, called *balsam of sulphur*. The connexion of phlogiston with vitriolic acid seems to be much weakened in the sulphur by the intervention of oil; for if balsam of sulphur be distilled, the sulphur will be totally, or in great measure decomposed, since only the same principles are obtained by this distillation as are obtained by distilling the combination of the oil with vitriolic acid. *See BALSAM of SULPHUR and SULPHUR.*

Alkalis act upon all oils, and combine with them to a certain degree, but more or less readily, according to the nature of the oil. In general, the less thin and volatile any oil is, the more easily soluble is it by alkalis; and reciprocally.

From the combination of an alkali with an oil results a compound more or less thick, called *soap*. The oil which enters into the composition of soap becomes easily miscible with water by means of the alkali, but is not perfectly dissolved in water; for the solution of soap has always a white milky appearance; which shews that the oil of soap dissolved in water is in a state similar to that of an emulsion. This proves at the same time that the combination of oils with alkalis is not intimate; accordingly the oil receives no alteration, or scarcely any from the alkalis: for it may be separated by means of any acid, and then it is found to be in the same state it was in before its entry into the soap. *See SOAP.*

Oils may be united with metallic substances. They attack most sensibly copper and lead. Oils dissolve copper even without heat, and from this solution results a blueish-green shining matter. The action of oils upon this and other metals is probably by means of their acid and phlogiston. The concurrence of the air perhaps facilitates this solution; perhaps even it is necessary.

Oils are most easily combinable with the calxes of lead, as minium, ceruss, and litharge, probably because these preparations are much divided, and the oils which have the greatest dissolving power are those which are the least thin and least volatile. When the calxes of lead are united only in small quantity with oil, they do not destroy its fluidity, but diminish it, and give to the oil the property of drying much more readily.

These oils, called *drying oils*, are much used in painting, from their drying quality. When a large quantity of calxes of lead is combined with oil, they form with it a solid, opaque, and tenacious body, capable of softening by heat. These combinations are useful in pharmacy, for giving a convenient consistence and tenacity to many plasters. Mr. Geoffroy has observed, that calxes of lead combined with oils form compounds which have some saponaceous characters; that they communicate to water nearly the same taste and unctuousity that soap does, and make it lather in the same manner; that the oil may be separated from the lead by means of acids, in the same manner as alkaline soaps may be decomposed; and that the oil thus separated is entirely similar to that obtained by decomposing soaps. These combinations of oils with metallic substances have been examined but superficially by chemists; nevertheless, they

present very interesting observations and particulars. We now proceed to the several kinds of oils.

CCCCCLXXXVII. O I L S (A N I M A L). All animal substances contain an oil, which is naturally unctuous, mild, and not volatile with the heat of boiling water. But, in general, the oil obtained from animals is in two very different states, which ought to be distinguished from each other.

The first state is that of butter and fat. This kind of animal oil is thick or congealed, and owes this quality to a considerable quantity of acid intimately combined with it, and which cannot be unfolded but by the action of fire, or by the rancidity it contracts in time.

The oil of animals, which is in form of butter or fat, is not combined with the other principles of animal matters. It is distinct from them, is superabundant to the animal composition, and is of a nature totally different from that which is combined with the animal substances. This superabundant animal oil, which may be called *adipous oil*, resembles perfectly wax, and those vegetable oils called properly *fat oils*; and, like these, it contains no other saline substance than an acid. The acid of these oily matters is more intimately combined than in other kinds of oils. Hence they are much less apt to become rancid, furnish less acid by repeated distillation, and are by this operation most difficultly rendered thin and volatile. See BUTTER, WAX, FAT, and OILS. (FAT).

The oils of this kind which are contained in animals are fat, marrow, the expressed oil of yolks of eggs, spermaceti, and others of this nature.

The second state, in which the oil of animals is found, is in that of combination. The substance which forms almost entirely all the parts composing animal bodies, as flesh, tendons, nerves, cartilages, bones, horns, hair, &c. is gelatinous, perfectly soluble in water, and which does not disturb the transparency of water. This matter being distilled, furnishes a large quantity of oil, which is one of the parts of the decomposed substance. See JELLY. As this oil does not appear in the gelatinous matter before it has been decomposed, and as this matter is perfectly soluble in water, we may infer that oil is one of the principles of jelly, and is rendered perfectly miscible with water by means of the saline principles of that matter; it is consequently in a state perfectly saponaceous.

When the gelatinous matter has received no alteration, the oil which it contains appears absolutely mild, and is not so volatile as to rise with the heat of boiling-water; for fresh animal matters furnish nothing by distillation with that heat but water, excepting those which have peculiar smells, as musk, castor, and others of that nature. But if a stronger heat be applied, they then furnish much volatile alkali, and an oil; the first portions of which are thin, penetrating, and volatile. This is the oil which ought to be considered as the true animal oil. It has a smell strongly empyreumatic, disagreeable, and mixed with that of volatile alkali. This oil becomes more and more thick as it rises in distillation, as is usual in the distillation of all oils.

This animal oil differs essentially from fat, and from all vegetable oils. The cause of this difference seems to be, that the former oil does not appear to furnish a single particle of acid, but rather volatile alkali; whereas the latter oils contain an acid, which is unfolded and separated by distillation.



**CCCCCLXXXVIII. OIL (ANIMAL) RECTIFIED, or OIL of DIPPET.** The animal oil described in the preceding article is susceptible, as other oils are, of being attenuated, and rendered more volatile, by repeated distillations. By a sufficient number of successive distillations, it may be rendered almost as white, thin, and volatile as ether. It is discovered to acquire a property of acting upon the brain and nervous system, and of allaying its irregular movements; which property is common to it with all other inflammable matters, when highly attenuated and very volatile. But this oil is particularly recommended for epileptic and convulsive affections. It is given from four to ten or twelve drops, incorporated with some proper vehicle.

The animal oil designed for medicinal uses must have the above-mentioned thinness, as Dippel has observed, whose name it retains: but it is then very dear, from the long and troublesome operations requisite to give it that thinness, and from the smallness of the quantity obtained. Besides, this oil, although perfectly well prepared, is very susceptible of losing its whiteness, and even its thinness, by a short exposure to air; which proceeds from the almost instantaneous evaporation of its more thin and volatile parts, and from the property which the less volatile remainder has of acquiring color. To avoid this inconvenience, it must be put, as soon as it is made, into very clean glass bottles, with glass stoppers, and exposed as little as possible to the air.

Although all animal substances contain this oil, they are not all equally fit for furnishing by distillation an oil capable of being rectified into a good oil of Dippel. For this purpose we ought to choose the parts of animals which contain the purest gelatinous substance, and which are entirely free from all fat; for the oil of fat, which necessarily mixes with the other oils in distillation, contains, as we have observed under the article **OIL (ANIMAL)**, a large portion of acid intimately combined with it, from which it is very difficultly separable, and therefore is not nearly so easily attenuated as the true animal oil; besides that one of these oils has an acid, and the other an alkaline quality, and therefore their medicinal effects are probably different. Accordingly, as the flesh, bones, blood of animals, contain always some oily substance of the nature of fat or marrow, they ought not to be chosen for the preparation of the oil of Dippel. Horns, and particularly those of stags, which contain very pure gelatinous matter, are the animal substances from which the greatest quantity of this oil can be obtained in good condition.

The most important observations concerning the method of making the oil of Dippel are: First, to change the vessels each distillation, or else to clean them perfectly; for a very small quantity of the thicker and less volatile part is sufficient to spoil a large quantity of that which is more rectified. In the second place, Mr. Beaume has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance.

**CCCCCLXXXIX. OILS (SWEET) obtained from VEGETABLES by EXPRESSION.** Vegetable matters, at least many.

many of them, contain an oil in two different states, as animal matters also do; that is, in vegetables a certain quantity of oil is superabundant to their combination, does not enter into the composition of their proximate principles, is distinct, and is deposited as a reserve in different parts of plants; and also in vegetables another quantity of oil is combined, and is one of the constituent parts of their proximate principles. Such are the saponaceous extractive substance, acids, essential salts, mucilaginous matters. Of the former of these vegetable oils we treat in this article. This superabundant and uncombined oil, which may be obtained from certain vegetables, may be distinguished into two kinds; one of which is acrid, volatile, and odoriferous, and is called *essential oil*; the other kind is mild, is not volatile with the heat of boiling water, and has scarcely any smell. Of this latter we shall first treat.

Most grains and kernels are the particular reservoirs of this superabundant oil. If these substances be bruised and pounded, this oil appears, and exudes from them. By triturating them with water, the oil is reduced into the state of an emulsion; and by expressing them, a very large quantity of oil is forced out of them.

When the grains and kernels from which oil is thus extracted are recent and preserved from rancidity, the oil obtained has a very mild taste. It is at first a little turbid, by mixture of some of the other parts of the grain or kernel; but these matters afterwards separate in form of sediment, and the oil becomes clear.

These oils are never very fluid and thin; on the contrary, they are considerably unctuous. They are not so volatile as to rise in distillation with the heat of boiling water, as we have already said; and when they are exposed to a heat so strong as to raise them into vapors, they then suffer a considerable alteration. Although they are mild and inodorous, yet by distillation they become very acrid and very empyreumatic. Although they are combustible, yet they cannot be inflamed merely by the touch of a kindled body, as all those inflammable matters may, which, by their volatility, are continually evaporating. Expressed oils cannot be inflamed without a wick, or without a heat sufficient to evaporate them.

Sweet expressed oils suffer by time several alterations; they lose much of their mildness, contract an acrimony, and a strong smell. These changes, which are called *rancidity*, are occasioned by a kind of internal fermentation, which produces effects similar to those of fire, but much more slowly and weakly. The acid which is intimately combined with these oils, and which does not show itself when they are recent and have not been altered, disengages itself more and more as they become old, in the same manner as it does by exposure to fire. This is the reason why they become acrid in both cases: for the same reason also, they acquire so much greater solubility in spirit of wine, (which they had not before) as they have become more rancid, or have been more frequently distilled. Mr. Macquer has shewn, in his *Memoir concerning the Difference of Solubility of Oily Substances in Spirit of Wine*, that this entirely depends on the state of the acid of these substances; that they are so much more soluble as their acid is more copious and disengaged; and reciprocally. We shall find some particulars upon this subject at the article *ESSENTIAL OIL*.

Of all oils, those of which we now treat are the most proper for combining with fixed alkalis, and for forming good soap (*see SOAP*); and also for dissolving metallic matters.

All the sweet superabundant oils in vegetables, and which are capable of being extracted merely by expression, resemble each other by the general properties we have mentioned: but they differ considerably from each other by the degree in which they possess these and other properties. Some of these oils, as of linseed, nuts, hempseed, are disposed to become rancid, to thicken, and to dry very quickly; they are capable of resisting a great degree of cold without being congealed; they form resinous compounds when mixed with vitriolic and nitrous acids, and are easily inflamed by the smoking nitrous acid, as Mr. Rouelle has observed. Other oils, as those of ben, olives, sweet almonds, wall-nut, &c. become much more slowly rancid and thick; they cannot be entirely dried; they congeal with a very slight degree of cold; they are less disposed to combine with the vitriolic and nitrous acids; they form with these acids compounds, which rather resemble fat or soap, as Mr. Beaumé remarks, than resins; and, lastly, cannot be inflamed, but by the concurrence of the vitriolic and nitrous acids highly concentrated. As these latter oils have, as to consistence, a perfect resemblance to *butter, fat, and wax* (*see these words*); and as they exhibit entirely the same phenomena, they justly deserve to be distinguished from all others by the particular denomination of *fat oils*.

In the class of these latter oils, we may range some concrete, oily, and mild matters obtained from vegetables; such are the *butter of cacao*, the *green wax of Louisiana*, and perhaps many others hitherto not sufficiently examined. We may easily perceive, that among the great number of sweet oils obtained by expression, and which are not volatile, several of them must more or less partake of the nature of one or other of the two principal kinds we have just mentioned.

**CCCCXC. OILS (ESSENTIAL).** Those oils are called *essential*, which have evidently the smell of the vegetable from which they are obtained. All these oils are sufficiently volatile to rise with the heat of boiling water: hence this degree of volatility is one of the specific marks of these oils. They differ from all others, and particularly from those mentioned in the preceding article, by this degree of volatility, which is peculiar to them.

We have reason to believe, that the greatest part of the essential oil, which certain vegetables contain, is in a state of combination, and makes part of some of their proximate principles. We are, however, certain, that many vegetables contain a superabundant essential oil, uncombined, and deposited as a reserve in particular cells: such is the oil which resides in the rinds of oranges, lemons, citrons, in a word, of all fruits of that kind; which oil is so copious, that it may be obtained merely by expression; such probably are those which are found most copiously and most manifestly in certain parts of plants; as the oil, for instance, which is found in the calix of roses, but in too small a quantity to be obtained by expression alone.

However that be, as all essential oils are capable of rising in distillation with the heat of boiling water; and as this degree of heat cannot occasion any sensible alteration upon them (as may easily be seen by comparing the essential oil of citrons and others, obtained by expression alone, with the oil of the

vegetable

vegetable extracted by a well managed distillation); by such a distillation, therefore, may be obtained almost all the essential oils employed in chemistry and in the arts.

The most usual and best method of obtaining the essential oil of a vegetable by distillation, is to take the plant in its prime of age, when its smell is the strongest, and to chuse those parts of the plant in which the smell chiefly resides; to put them in the cucurbit of an alembic without a water-bath; to add as much water as is sufficient to prevent the plants from touching the bottom of the vessel; to adjust a worm to the nose of the alembic; and to give at once the degree of heat which is proper to make the water boil.

In this distillation, the water rises impregnated with the smell of the plant, and it carries along with it all its essential oil. A part of this oil is so intimately mixed with the water which rises in distillation, that it renders it turbid and milky; the rest of the oil floats upon the surface of the water, or sinks to the bottom, according to its specific gravity. The distillation is thus to be continued, till we perceive that the water becomes clear; and more water must, from time to time, be put into the cucurbit, that the plant may be always kept moist with it. We shall see the reason of the several parts of this process in the explanation of the particular properties of essential oils.

Not only these oils have all a strong, aromatic smell, as we have already said, but they have also a singular, and even an acrid and caustic taste; in which respect they differ from the sweet oils. This taste proceeds from a copious and disengaged acid, with which they are all penetrated.

The presence of this disengaged acid in essential oils appears from the impression they make upon the corks of bottles, in which they are kept. These corks are always stained of a yellow color, and a little corroded, nearly as they are by nitrous acid. Besides, the vapor of these oils reddens blue paper; and the oils convert alkalis, with which they are triturated, into a neutral salt.

This acid is the cause of the solubility of essential oils in spirit of wine. They are not all equally soluble in this menstruum, because they do not all contain an equal quantity of acid. As this acid is almost disengaged, and does not adhere strongly in these oils, they lose much of it by repeated distillations, and therefore their solubility in spirit of wine is lessened by these operations; whereas sweet oils, which, when recent, contain no disengaged acid, and are therefore insoluble in spirit of wine, become soluble in that menstruum by distillation, which disengages their latent acid, that was intimately combined with them; and this solubility may be increased by repeating many times the distillation, as Mr. Macquer has proved in the Memoir quoted in the preceding article.

All essential oils are subject to lose, by evaporation, their most volatile and thin part, in which the specific smell of the vegetable, from which they are obtained, resides; by which loss they become thick, and acquire the consistence and smell of turpentine, or even of resins.

When in this state, they are not, properly speaking, essential oils, as they are no longer volatile with the heat of boiling water.

When essential oils, altered by time, but not yet entirely deprived of their peculiar smell, are distilled with the heat of boiling water, a part of them rises in distillation, which has all the properties of essential oil freshly distilled. As this

this portion of oil is renewed by this operation, it is frequently practised on essential oils, which begin to be altered by age; and this second distillation is called the *rectification of essential oils*. We find in the cucurbit, after rectification, the resinous portion of the oil, which is no longer capable of being raised by the heat of boiling water. This oily residuum may, however, be attenuated by distilling with a stronger heat, and even all the volatility and thinness of essential oils may be given to it, as also to all other oily matters, by distillations sufficiently repeated. But such oils have never the peculiar aromatic smell of the original essential oil.

From these properties of essential oil, we may conclude, that they receive their specific character from their volatile odoriferous principle, that is, from the *spiritus rector* of the substance from which they were obtained; since they have the smell, thinness, and volatility which distinguish them, while they preserve this principle, and lose all these properties when it evaporates.

These facts also shew the necessity of applying very quickly the degree of heat requisite for the raising of these oils in distillation; for we may easily perceive, that as the spiritus rector is capable of rising with a heat much less than that of boiling water, (which is necessary for raising essential oils) this spirit will rise alone, when the heat is less than that of boiling water, and the quantity of essential oil obtained will be diminished; so that if the distillation be continued with a less heat than that of boiling water, till the plant has lost all the smell which it can lose by this heat, no essential oil can then be obtained, or only a much less quantity of it.

As the spiritus rector is entirely soluble in water, therefore the water employed in this distillation of essential oils dissolves a large portion of this spirit, and even becomes saturated with it. Accordingly, this water is much impregnated with the smell of the plant; but the oil by this means is in less quantity than it otherwise would be.

Hence we may infer, first, that no more water than is necessary ought to be employed; and, secondly, that the water which has thus risen with the oil ought to be employed for other distillations preferably to pure water.

This water is not only much impregnated with the odoriferous principle of plants, but also it contains a considerable quantity of the thinnest part of the essential oil, from which it receives a milky appearance. This portion of oil sometimes remains a long time suspended and half-dissolved, by means of the spiritus rector: but, in time, a certain quantity of it is always separated, which may be collected.

Essential oils are in general the most inflammable of all oils, because they are the most volatile, and most easily reducible into vapors.

They unite more easily with acids than the sweet oils which are not volatile.

With these acids they form resinous compounds, or are inflamed, according to the nature and degree of concentration of the acid employed.

They are more difficultly combinable than the sweet oils which are not volatile, with fixed alkalis, with which they form a particular kind of soap. See *SOAP of STARKEY*.

Some considerable differences may be observed betwixt the several essential oils. Although, in general, they are all capable of rising with the heat of boiling water, some of them, however, may be obtained in a larger quantity by  
O o o a heat

a heat somewhat stronger; and this is effected by mixing with the water salts (as common salt) which are incapable of acting upon oils, and by means of which the water is capable of receiving a stronger heat.

The specific gravity of most of these oils is less than that of water, and accordingly they float upon the surface of this liquid. Some of these oils, however, are so heavy as to sink in water; of this kind are the essential oils obtained from the aromatic vegetables of hot countries, as cloves, cinnamon, saffra, &c. To the distillation of these heavy oils a stronger heat is chiefly useful. Dry, woody, and compact matters, previously to the distillation of their essential oils, require the assistance of division and maceration during some days.

The consistence of essential oils varies much; some of them, as those of turpentine, saffra, and citron, being very thin; and others, like those of aniseed and roses, have naturally much consistence, and are even congealed, unless they sustain a certain degree of heat.

Although the weight and consistence of essential oils proceed probably from the state of their acid, as well as all the other differences betwixt them, yet these two properties seem to be independent of each other; for some oils are, at the same time, very thin and very heavy, while others are very light and thick. The oil of saffra, which is very fluid, is heavier than water; on the contrary, the oil of aniseed, the consistence of which is sometimes equal to that of congelation, floats upon water.

The quantity of essential oil obtained from different vegetables is very various. Some vegetable substances, as safin, turpentine, and most balsamic and resinous trees, furnish a large quantity of oil. From others, as roses, for instance, scarcely a sensible quantity of it is obtainable; and, lastly, others, although they contain much spiritus rector, and have much smell, furnish no essential oil by distillation: of this number are lillies, tuberoses, and jasmine.

Essential oils are employed in painting, in spirituous liquors used at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, small doses only are given internally, as from one drop to four or five, incorporated with sugar, so as to form an oleosacharum, or with other drugs in form of pills.

These oils being inflammable, thin, and volatile, have in general a property of acting upon the nervous system, and of allaying its irregular movements: it is therefore given as a cephalic, and antispasmodic, in convulsive and hysterical affections; they are also stimulant, sudorific, and strengthening. All drugs which are alexipharmac, cephalic, tonic, and stomachic, which contain vegetable aromatics, derive their virtues from the essential oils of these vegetables. The same may be said of all medicinal, aromatic, and spirituous waters.

In some cases, essential oils are employed externally as strengtheners, and to allay painful spasms of nervous and tendinous parts, to resolve and dissipate acrid humors, which occasion pain without any sensible sign of inflammation. When essential oils are applied externally in these cases, they are so caustic that they must not be applied alone, as they would excite pain, redness, frequently inflammation, erysipelatous eruptions, and excoriations. They are a kind of vesicatory. The best method of avoiding these inconveniences is, by mixing them

them with a sufficient quantity of fat, or of fat oil, to form liniments or pomatums, with which the diseased parts may be rubbed.

The essential oils, which are obtained from scarce and valuable substances, must also be very dear, and are therefore subject to much adulteration. Most of the books of chemistry explain the manner of making, or of discovering these adulterations. We shall only, in a summary manner, mention what is most important to be known on this subject.

Essential oils may be adulterated with any flavorless fat oil, with spirit of wine, or with any common and cheap essential oil. They who know the properties of these substances may easily discover the fraud. As fat oils are neither volatile nor drying, if a drop of the essential oil, to be examined, be put upon paper, it may be evaporated with a gentle heat; and when it is unmixed with fat oil, it will leave no greasiness nor transparency in the paper. This mixture may also be discovered by mixing a drop of the essential oil with spirit of wine, by which it will be entirely dissolved if it be pure from fat oil; but if it has been adulterated with this latter kind of oil, this will remain undissolved in spirit of wine.

The mixture of spirit of wine with an essential oil may be discovered by addition of water, which immediately acquires a milky appearance; because the spirit of wine quits the oil to unite with the water, and leaves the oil much divided and suspended, but not dissolved. This does not happen when the essential oil has not been adulterated with spirit of wine. Pure essential oil may, indeed, by agitation with water, be divided into small globules, and may give a whiteness to the water: but these globules quickly unite again on the surface, or at the bottom of the water, according to their specific gravity.

Lastly, adulteration by another essential oil is most difficultly discoverable; because the principal properties of these oils are common to all. Nevertheless, as essential oils are commonly adulterated with oil of turpentine, this fraud may be discovered by soaking a bit of paper or linen with the oil to be examined, and by quickly evaporating the oil, which will leave upon the linen or paper a strong smell of turpentine.

**CCCCXCI. OILS (FETID, EMPYREUMATIC).** Under this name we comprehend all the oils of vegetable and animal matters obtained by distillation with a heat superior to that of boiling water; because these oils have a disagreeable, burnt, or empyreumatic smell.

From this definition we see, that empyreumatic oils are not a distinct class; that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is exposed to a degree of heat superior to that of boiling water, all the oils which they contain, of whatever kind they may be, pass in distillation; but are altered, by the fire, in their color, smell, and in many other of their peculiar properties. Besides, if the matter thus distilled contains several kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be distilled, which contains an oil that is sweet and not volatile, and also an oil in a resinous state, the fetid empyreumatic oil obtained will be only a mixture of these two oils half-burnt. The same may be said of animal matters with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be established as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are composed. Hence, if we would know the properties of any empyreumatic oil, we must previously know the kinds and proportion of oils contained in the substance from which it has been obtained, and also the changes suffered by each of these oils by the degree of heat requisite to render them empyreumatic. We shall here only observe, that all empyreumatic oils are acrid, and more or less soluble in spirit of wine; that the portion of these oils which rises first in distillation is always the thinnest; that by repeated distillations they may be rendered more and more thin and volatile; and that by a sufficient repetition of these rectifications, we may almost entirely deprive them of their empyreumatic smell, so that only a pungent and penetrating smell shall remain; which seems to be common to all oils treated in this manner.

CCCCXCII. O I L S, *improperly so called*. Many preparations were by the ancient chemists called *oils*, merely from their consistence, although in other respects they were entirely different from oil. These improper names ought to be abolished, and they are accordingly falling into disuse by modern chemists. Nevertheless, as they are found in most chemical books in the time of Lemerî, and as many of them are still frequently employed, we shall explain in a few words the chief of them.

CCCCXCIII. O I L of A N T I M O N Y. By this name the butter of antimony, and some other solutions of antimony by acids, are called. See BUTTER of ANTIMONY.

CCCCXCIV. O I L of A R S E N I C. This is a combination of concentrated marine acid with arsenic, and is made precisely in the same manner as butter of antimony. Equal parts of arsenic and of corrosive sublimate are mixed and distilled together, by which a liquor is distilled, similar to the butter of antimony. This is a very powerful, but, at the same time, very dangerous caustic. This shews, that arsenic, like regulus of antimony and several other metallic substances, is capable of decomposing corrosive sublimate by seizing its acid. Accordingly, mercury is revived in this as in all the similar operations.

CCCCXCV. O I L of M E R C U R Y. When water is added to a solution of mercury in vitriolic acid to form the precipitate called *turbith mineral*, the acid thus diluted still retains a portion of mercury dissolved, which is properly a vitriol of mercury. This salt, which is crystallizable, may be obtained by evaporating the water which keeps it dissolved. When exposed to a moist air, it deliquesces into a liquor which Lemerî calls *oil of mercury*. See TURBITH MINERAL.

Lemerî also gives the name of *oil of mercury* to a solution of corrosive sublimate in spirit of wine.

CCCCXCVI. O I L of L E A D. This is a solution of salt of lead in the essential oil of turpentine. This salt is to be put into a matrass, and upon it oil of turpentine is to be poured, till it covers the salt with a thickness of some fingers, and the whole is to be digested during ten or twelve hours. The liquor, says Lemerî, acquires a red color. That author directs that the solution should be concentrated, by distilling from it a part of the oil of turpentine, and he recommends it for its utility in cleansing and cicatrizing ulcers, particularly



icularly those which are putrid. This preparation, which is certainly a powerful antiseptic, must be very proper for these purposes.

Amongst the oils improperly so called, this is one of those to which the name of oil has been with least impropriety given; for the basis of it is actually oil, and that oil really keeps the lead in solution. Lemerî affirms, that we may thus entirely dissolve a given quantity of salt of lead, by employing a sufficient quantity of oil of turpentine. This preparation, which has only been made for medicinal purposes, is interesting also in chemistry, and deserves a particular examination.

CCCCXCVII. OIL of SULPHUR. Some chemists have given this name to the concentrated acid of sulphur. See SULPHUR.

CCCCXCVIII. OIL of TARTAR by DELIQUIMUM. This name very frequently is given to fixed alkaline salt resolved into a liquor by the moisture of the air, or even to a solution of that salt in water. This name is unsuitable, not only as this liquor is not of the nature of oil, but also because a true oil of tartar is obtained by distillation of tartar. This liquor ought to be called *alkali of tartar*, or *liquid vegetable alkali*. See ALKALI (FIXED VEGETABLE), and TARTAR.

CCCCXCIX. OIL of VENUS. Lemerî gives this name to the salt formed by the union of copper with the nitrous acid, when it is resolved into a liquor by the moisture of the air. It is a caustic and escharotic, like all other similar combinations of metallic matters with any acids to which the name of oil was formerly given. An empirical physician has rendered this name of oil of Venus famous in these latter times, by having applied it to a ratafiat of his composition, which has been found agreeable, and has been much in vogue.

D. OIL of VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. See ACID (VITRIOLIC), and VITRIOL.

DI. OLEOSACHARUM. This name is given to a mixture of oil and sugar incorporated with each other, to render the oil more easily diffusible in watery liquors. Sugar and all saccharine matters have in general a quality somewhat saponaceous, and consequently are capable of producing this effect in some measure. These oleosacharums are used in pharmacy as a method of administering essential and other oils. See OILS and JUICES (SACCHARINE).

DII. OLIBANUM. (s)

DIII. ONIONS. (s)

DIV. OPAL. (u)

(s) OLIBANUM, *thus, frankincense*, is a gum-resin, of an ounce of which water is capable of dissolving three drams and a scruple, and spirit of wine is capable of dissolving five drams and two scruples. *Neuman.*

(s) ONIONS. This root has an essential oil, which impregnates water in distillation with a very strong smell, and which is so miscible with the distilled water, that it

cannot be collected separately. The oil may also be combined with spirit of wine by distillation. From an ounce of the dry root six drams of extract may be obtained by spirit of wine, and somewhat more may be obtained by water. *Neuman.*

(u) OPAL is an almost pellucid agate, the color of which varies by reflexion and refraction. Opals are milk-colored; blackish, yellowish, or greenish; which latter variety

DV. O N Y X. (x)

DVI. O P I U M. (y)

DVII. O P O P O N A X. (z)

DVIII. O R A N G E. (a)

DIX. O R E S. Ores are natural compounds, containing metals allayed with different substances.

Excepting gold, and a very small quantity of each of the other metals found in some places so pure as to possess all their characteristic properties, nature exhibits to us metals and semimetals differently allayed not only with each other, but also with several heterogeneous substances, which so alter and disguise their qualities, that in this state they cannot serve for any of the purposes for which they are proper when they are sufficiently pure.

The substances found naturally combined with metals, in the earth, are, particularly, sulphur and arsenic, sometimes separately, but generally conjointly.

is called *cats eye*. Opals are classed among the siliceous order of earths, although some of them are so soft as to be capable of being scratched with a knife. The *oculus mundi* is a rare but curious variety of the opal. It is opaque, and generally of a yellowish color; but by being immerged during some hours in water, becomes transparent, and acquires a bright yellow, or even a luminous flame-color.

(x) ONYX is an agate, generally opaque, or but slightly transparent, consisting of differently colored veins, parallel to each other, sometimes in straight and sometimes in curve lines. See AGATE.

(y) OPIUM is almost totally soluble in water or in spirit of wine. It contains a resin, a gum, a minute portion of saline acidulous matter, water, and earth. On what its peculiar properties depend we do not well know. When opium is dissolved in water, a fat, frothy, resinous substance rises to the surface, which is so strong and active, that a few grains of it are sufficient to kill a dog who could bear a whole dram of opium. From a pound of opium two or three drams only of this substance may be collected; but the opium contains more of it, which remains combined with the rest of the juice. The narcotic matter of the opium appears to be diffused through all its substance, but more especially to reside in the fine volatile parts; which parts are capable of being highly concentrated by art. Neuman (from whom the above is extracted) says, that he knows a preparation of opium by which a whole chamber full of men may

be presently stupefied, deprived of their senses, and even of their lives, without swallowing a single grain. He thinks that it operates nearly in the same manner as the vapor of burning charcoal, or as the exhalations of fermenting liquors. The same author proposes to render opium more mild and innocent, by dissolving it in water and fermenting the solution. Dr. Lewis observes, that diminishing the dose of opium is a more certain method of diminishing its effects. He also says, that alkaline salts diminish the soporific power of opium, and that acids almost totally destroy it.

(z) OPOPONAX is a gum-resin, of an ounce of which two drams and two scruples are soluble by spirit of wine, and three drams two scruples are soluble by water. Both water and spirit, by distillation with opoponax, acquire its flavor; but no oil is thereby separated. Neuman.

(a) ORANGE. The flowers of orange trees afford, by distillation, a very fragrant essential oil. From the rind of the fruit an essential oil may be obtained by expression. The juice of the fruit contains an essential acid salt, mixed with much mucilage. This salt may be obtained in crystals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a saline extract may be made, capable of being preserved, and possessed of the same medicinal qualities as the juice, which is said to be very powerful in the scurvy.

Metals

Metals combined with these substances are called *metals mineralised by sulphur*, or by *arsenic*, or by *sulphur and arsenic*; and these matters are called *mineralising* substances.

Besides the sulphur and arsenic with which metals are strictly combined in the mineral state, they are also pretty intimately combined with earthy substances, of different natures, and more or less divided. A part of this earth is disposed to metallisation, and is convertible into a metal by combination with phlogiston. It is called *metallic earth*, and probably proceeds from a portion of metal which has been decomposed, and destroyed in its ore by different causes, which we shall mention afterwards. Perhaps also this earth may be only a simple earth naturally disposed to metallisation, or the first beginning of a metal which nature has not yet brought completely to a metallic state.

We are to observe upon the subject of this metallic earth, that it is found not only amongst mineralised metals, but that it appears diffused, although in very small quantity, in large masses of ordinary earth which is found every where, such as sands, clays, and mud. Mr. Cramer thinks that the experiments mentioned by Beccher in his third Supplement to his *Physica Subterranea*, by which he extracts gold or iron from any sands or clays, are demonstrative upon this subject. The other portion of earth which is intimately mixed with mineralised metals, cannot be reduced into metals, and is therefore called *unmetallic earth*. This is an ordinary earth.

These different matters united together form masses which are compact, heavy, brittle, and frequently possessed of much metallic lustre. These substances are properly called *ores*, or the matter of mines.

These ores are found in earths and stones of different kinds, as sands, flints, crystals, slates, indurated clays, according to the ground in which they are contained. But two kinds of stones in particular seem to accompany ores, and have therefore been considered by several mineralogists as matrixes, in which metals are formed. One of these stones is a kind of crystal, generally white, milky, and semi-opaque, striking fire with steel, and of the class of vitrifiable earths. It is called *quartz*. See QUARTZ.

The other stone is less hard, which does not strike fire with steel, and is sometimes milky like quartz; sometimes transparent and diversely colored, consisting of rhomboidal crystals, which are composed of plates and faces. This stone becomes more soft and friable by being exposed to fire. It is called *spar*. Spar is more like to gypseous stones than to any other, but it differs from gypseous stones in possessing a much greater density. Some spars are so heavy, that they exceed in this respect all other stones. See SPAR.

These earthy and stoney substances ought to be well distinguished from the earth intimately mixed with the ore, as is mentioned above; this latter earth constituting part of the ore, whereas the others are only accidental, and externally adherent. They form the *matrix of the ore*.

*Mines* have generally the form of veins, or of congealed currents, which have different directions, and which are distributed in branches. The mines take different appellations according to the direction of their veins.

The *deep mines* are those which descend from the surface of the earth, either vertically, or more or less obliquely towards its center.

Those

Those which are extended horizontally are called *dilated mines*, because they frequently are considerably broad.

Some mines compose masses more or less extensive, and almost equally long, broad, and thick. These latter are called *accumulated mines*.

Some authors have said that the veins of mines are always directed from east to west, from north to south, or in the intermediate directions, according to the nature of the metals. But this opinion is not well supported by facts; for we are certain that veins of every metal run in every direction. The direction of mines is determined by their descent, like that of rivers, and by help of a mariner's compass.

From several signs we may know that a field or a mountain contains a mine, particularly when the mine is near the surface of the earth. For, from grounds filled with minerals, sulphureous and metallic vapors rise, which are sometimes so considerable as to affect the senses, but which most frequently only shew themselves by the effects which they produce on plants, which they render weakly, and discolored. Frequently even, mineralogists say, these places are entirely barren, and no vegetables grow there, although the ground seems to be of a good quality, and fit for vegetation.

The sources of mineral waters; the nature of the stones upon the ground being that of quartz or spar; bits of minerals lying on the ground; are so many proofs of the presence of mines.

But we must not altogether depend on these signs; for notwithstanding them, we often find no mines, or very poor ones, when we dig the ground.

The digging of the ground is then the only certain method of determining the existence of a mine, and of what kind it is; for the *wand of divination*, by which many pretend that mines and their quality may be discovered, is a chimera, which owes its reputation to credulity and ignorance.

Metallic minerals are divided into two classes. The first includes all those, in which the quantity of metal exceeds the quantity of sulphur, arsenic, and unmetallic earth; or from which metal may be advantageously extracted. These minerals are particularly called *ores*.

In the second class are placed all minerals which contain more sulphur, arsenic, and unmetallic earth than metal; and these in general are called *pyrites*.

Pyrites and ores are of the same nature, and are often both found in the same places. But as the proportion of the principles of these compounds is different, their properties also differ. We shall explain the properties of pyrites under the article *pyrites*, and the properties of ores in this present article.

Ores may be considered in two ways; first, as containing useful and valuable substances, and they then receive their name from the most valuable metal which is obtained from them. Thus, for instance, as silver is much more valuable than lead, a mineral, a quintal of which contains a mark of silver, and sixty pounds of lead, or more, is called *an ore of silver*, because the mark of silver is more valuable than the 60 pounds of lead. This manner of denominating ores is chiefly used by the miners.

In the second place, we may chiefly attend to the metal the largest quantity of which is contained in a mineral, without attending to its value, and affix its name to the ore. In this manner, the ore just now mentioned would be called

called an ore of lead, and not an ore of silver. But the best method seems to be, to call such an ore an ore of lead containing silver, as is very frequently done.

Mr. Cramer, a profound and judicious chemist, who has particularly attended to this subject, thinks that we ought to call an ore, the proper ore of that metal which it contains in largest quantity, and to call it the improper ore of all the other metals it may contain. This method of distinguishing ores is certainly one of the best and most exact. We shall now give a summary description of the principal kinds of ores of each metallic substance. (b).

(b) As metallurgy is the most important part of chemistry, we hope that a sketch of the History of Mines, and a more particular enumeration of ores than is contained in the text, together with a relation of the most approved methods of extracting metals from ores, for the purposes of essay, or of commerce and manufacture, may be not unacceptable. In the present Note, we shall treat of mines, and of ores in general: Under the articles in the text, which treat of the ores of the several metals, we shall subjoin an enumeration of those which are there omitted, and also the methods of assaying the several ores to discover the quantities and qualities of their contents: Lastly, under the article, SMELTING OF ORES, we shall make some additions concerning the methods of extracting metals from large quantities of ores for the purposes of commerce and manufacture.

### Concerning ORES and MINES.

ORES consist, 1. Of metallic substances calcined; or, 2. Of these substances combined with other matters, with which they are said to be mineralised.

Calcined metallic substances, or calciform ores, are metallic substances deprived of phlogiston, and in the state of a calx, or metallic earth. See CALX. Such are all ferruginous schists, which are calxes of iron.

Mineralised ores are, 1. Simple, containing only one metallic substance: or, 2. Compound, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished.

1. Ores consisting of metallic substances mineralised by sulphur. Such is the lead-ore called galena, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralised by arsenic. Such is the white pyrites, containing iron and arsenic.

3. Ores consisting of metallic substances mineralised by sulphur and by arsenic. Such is the red silver-ore, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances mineralised by saline matters. Such are the native vitriols. Such also is probably the cornuous silver-ore, which, according to Mr. Cronstedt's opinion, is a luna cornea, or silver combined with marine acid. Of this kind of ores, or native metallic salts, is perhaps the sedative salt of borax, which appears, from Mr. Cadet's experiments, published in the Memoirs of the Royal Academy for the year 1766, to be copper combined with marine acid, and which has been said to be found native. To this class also may be referred the silver mineralised by an alkaline substance, which Mr. Von Justi pretends to have discovered.

Henckel, and after him Cramer, and the author of the Dictionary of Chemistry, pretend that in mineralised ores, besides the above-mentioned metallic and mineralising substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shewn, and that sulphur is incapable of dissolving unmetallic earths, and even the calxes of all metallic substances, excepting those of lead, bismuth, and nickel.

Having thus defined and distinguished the several general classes of ores, we proceed to shew how they are lodged, and where they are found.

Metals and metalliferous ores are found in various places. I. They are found under water; in beds of rivers, lakes and seas, and chiefly at the flexures of these: Such are the

O

**DX. ORES of GOLD.** In taking the word *ore* in the sense above-mentioned, no ores of gold exist: for as this metal cannot be allayed

the auriferous and ferruginous sands, grains of native gold; ochres; and fragments of ores washed from mines.

II. They are found *dissolved in water*: Such are the vitriolic waters containing iron, copper, or zinc.

III. They are found *upon the surface of the earth*. Such are many ochres; metalliferous stones, sands, and clays; and lumps of ores. Mr. Gmelin says, that in the northern parts of Asia, ores are almost always found upon or near the surface of the ground.

IV. They are found *under the surface of the earth*. When the quantity of these collected in one place is considerable, it is called a *mine*.

Subterranean metals and ores are differently disposed in different places.

1. Some are *infixd in stones and earths*, forming *nodules* or *spots* diversely colored.

2. Some are *equally and uniformly diffused through the substance of earths and stones*, to which they give color, density, and other properties. Such are the greatest part of those earths, stones, sands, clays, crystals, flints, gems, and fluors, which are colored.

3. Some form *strata* in mountains. Such are the strata containing pyrites, copper-ore, lead-ore, silver-ore, or blend. These lie in the same direction as the strata of stones betwixt which they are placed, but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metalliferous stratum is often very various; whereas the thickness of the stoney strata is known to be generally very uniform.

4. *Fragments of ores* are frequently found accumulated in certain subterranean cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not accreted to the contiguous rocks or strata immediately, nor by intervention of spar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described.

5. Large entire masses of ores are sometimes found in the stoney strata of mountains. These are improperly called *cumulated veins*, because their length relatively to their breadth and depth, is not considerable.

6. Some instances are mentioned of *entire mountains* consisting of ore. Such is the mountain Taberg in Smoland; and such are the mountains of Kerunavara and Luosavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron-ore.

9. Lastly, and chiefly, metals and ores are found in oblong tracts, forming masses called *veins*, which lie in the stoney strata composing mountains.

The direction of veins greatly varies; some being straight, and others curved. Their position also respecting the horizon is very various; some being perpendicular, some horizontal, and the rest being of the intermediate degrees of declivity.

The dimensions, the quality, and the quantity of contents, and many other circumstances of veins, are also very various. Miners distinguish the several kinds of veins by names expressive of their differences. Thus veins are said to be *deep*; *perpendicular*; *horizontal*, or *banging*, or *dilated*; *rich*; *poor*; *morning*, *noon*, *evening*, and *night* veins, by which their direction towards that point of the compass where the sun is at any of these divisions of the natural day, is signified.

The stratum of earth or stone lying above a vein is called its *roof*: and the stratum under the vein is called its *floor*.

Some parts of veins are considerably thicker than others. Small veins frequently branch out from large veins, and sometimes these branches return into the trunk from which they issued. These veins, from which many smaller veins depart, have been observed to be generally rich.

*Veins are terminated* variously; 1. By a gradual diminution, as if they had been compressed, while yet soft, by superincumbent weight; or by splitting and dividing into several smaller veins: or, 2. They are terminated abruptly, together with their proper strata in which they lie. This abrupt termination of veins and strata is occasioned by their being crossed by new strata running transversely to the direction of the former; or by perpendicular fissures through the strata; which fissures are frequently

with arsenic, nor with sulphur, it is never found directly mineralised by these substances, as the other metals are. In the second place, if it be mineralised

quently filled with alluvial matters, or with water, or are empty. These perpendicular fissures seem to have been occasioned by some rupture or derangement of the stratum through which the vein passes, by which one part of it has been raised or depressed, or removed aside from the other, probably by earthquakes. Where the vein is terminated abruptly, it does not cease, but is only broken and disjoined; and is often recovered by searching in the analogous parts of the opposite side of the deranged stratum. A principal part of the art of miners consists in discovering the modes of these derangements from external marks, that they may know where to search for the disjoined vein.

The *contents of veins* are metals and metalliferous minerals, as, the several kinds of ores, pyrites, blends, guhrs, vitriols; the several kinds of fluors, spars, quartz, hornblend, in which the ores are generally imbedded, or enveloped, and to which therefore the name, *matrix of the ore*, is applied; stalactites; crystallizations of these metalliferous and stoney substances encrusting the small cavities of the circumjacent rock; and lastly, water, which flows or drops through crevices in that rock.

In a vein, ores are found sometimes attached to the rock or stratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and sometimes both these kinds of adhesion occur in the same vein at different places. Frequently betwixt the matrix and the rock is interposed a thin crust of stone or of earth, called by authors the *subria of the ore*.

The *matrix* or the stone in which the ore lies enveloped is of various kinds in different veins. And some kinds of stone seem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, spar, fluors, and hornblend give reception to all ores and metals; but flates, chiefly to copper and silver, and never to tin; calcareous and sparry matrixes, to lead, silver, and tin; and mica to iron.

*Veins* lie in strata of different kinds of stone; but more frequently in some kinds of stone than in others. Some are of the simple or uncompounded stones which compose

strata, the following are metalliferous: *calcareous stones*; *slaty sand-stone* (cos fissilis arenosus Walleri); *felspar* (spatum pyramichum five scintillans); *quartz*; sometimes *jasper*; frequently *flates*; and chiefly *micaceous* or *slaty stones*; and *hornblend* (lapis corneus Walleri; bolus indurata particulis squamosis Cronstedt). No veins have been found in gypsaceous or in siliceous strata, altho' *chert* and *flints* frequently contain metallic particles, and some instances have been observed of ores of silver and of tin in *alabaster*. Of compound stones, those are said to be chiefly metalliferous which consist of particles of hornblend. Veins have also been found in the *red granite*; but seldom, if ever, in any other *granite*, or in *porphyry*. In general, veins are more frequently found in soft, fissile, and friable strata, than in those which are compact and hard.

A vein sometimes passes from one stratum into the inferior contiguous stratum. Sometimes even the veins of one stratum do so correspond with those of an inferior stratum, the contiguity of which with the former is interrupted by a mass of different matter through which the veins do not pass, that they seem originally to have been continued from one stratum to the other. Thus in the mines of Derbyshire, where the veins lie in strata of limestone, the contiguity of which strata with each other is interrupted in some places by a blue marle or clay, and in other places by a compound stone called *toadstone*; the veins of one stratum frequently correspond with the veins of the inferior stratum of limestone, but are never continued through the interposed clay or toadstone. But we must observe, that these interposed masses, the blue marle, clay, and toadstone, have not the uniform thickness observable in regular strata, but are (especially the toadstone) in some places a few feet in depth, and in others some hundreds of yards. The above disposition seems to indicate, that these several strata of limestone have been originally contiguous; that the veins now disjoined have been once continued; that these strata of limestone have been afterwards separated by some violent cause, probably by the same earthquakes which have in a singular manner

indirectly by the union it contracts with other metals naturally combined with sulphur and arsenic, so small a quantity of it only is found in these ores, that they scarcely even deserve the name of *improper ores of gold*.

ner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled up with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; and, lastly, that these shattered strata have consisted of argillaceous and of calcareous earths, as appears from the clay; from the marle, which is a mixture of clay and calcareous earth; and from the toadstone, which consists of particles of hornblend (which Mr. Cronstedt justly considers as an indurated bole or clay) mixed with particles of calcareous earth.

To the above historical sketch of mines we shall add some conjectural remarks concerning their *formation*.

Those ores which are found under water (I.); upon the surface of the earth (III.); in fissures of mountains and subterranean cavities, accumulated, but not accreted to the contiguous rocks, (IV. 4.) seem from their loose, unconnected, broken appearance, to have been conveyed by alluvion.

All martial ochres have probably been separated from vitriolic ferruginous waters (II.) either spontaneously or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the vitriol which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and perhaps of several other metals, have probably been precipitated from vitriolic waters by some substance, as calcareous earth, more disposed to combine with acids; and these vitriolic waters have probably been rendered metalliferous, by dissolving the vitriols produced by a combustion of cupreous pyrites, and of blend; for these minerals are not, as martial pyrites is, susceptible of decomposition, spontaneously, or by air and moisture.

The metalliferous nodules and spots (IV. 1.) seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion, crystallized distinctly, as different salts do, when dissolved in the same fluid.

The earths and stones uniformly colored by metals (IV. 2.) were also probably in a soft state while they received these tinges. The opaque-colored stones seem to have received their color from metallic calxes mixed and diffused through the soft lapideous substance; and the transparent-colored stones have probably received their colors from vitriolic salts, or from metallic particles dissolved in the same water which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water, appears probable not only from their regular crystallized forms, but also from the solubility of some stones, as of gypseous and calcareous earths, in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called *cumulated*, (IV. 5.) and the entirely metalliferous mountains (IV. 6.) are believed by Wallerius to be analogous to the nodules (IV. 1.). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV. 3.) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which we supposed that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterwards crystallize, and form entire regular masses; or they may have been the ruins of shattered strata and veins brought by waters, and there deposited; in which case they will appear broken and irregular. These metalliferous strata, although frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these by the following properties: 1. They are generally thinner and much broader than the veins called dilated. 2. They are seldom found at a greater depth than a hundred perches, and generally in the neighbourhood



Hence gold is found either in its natural state, of a certain degree of purity, possessed of all its properties, or engaged with some other metals in certain minerals.

of veins, from which they probably have received their contents. 3. From their want of the thin encrustations called *malin*, which, we observed, are frequently interposed betwixt the rock and the ore or its matrix; and from their want of the other properties of veins.

But in *veins*, properly so called, the strongest marks exist of ores having been there concreted, and not deposited in their present state. Their regular, unbroken appearance, their accretion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix enveloping the ore, the frequent crystallization of the ore and of the other contents of the vein, indicate, that ores, as well as the other solid contents, have been there concreted from a fluid to a solid state.

Most authors believe, that veins, and the perpendicular clefts in the stony strata of mountains, called *Fissures*, have been produced by the same cause; or rather, they consider veins only as fissures filled with metalliferous matters. They further believe, that fissures have been occasioned by the exsiccation of strata, while these were passing from a fluid to a solid state. Wallerius thinks, that fissures have been formed from exsiccation, but that veins were channels made through the strata, while yet soft and fluid, by water, or by the more fluid parts of the strata penetrating and forcing a passage through the more solid parts. He thinks, that these fluid parts conveyed thither their metalliferous and stony contents, which were there coagulated or concreted. He supports his opinion by observing, that all the veins of the same stratum generally run parallel to each other; that they frequently bend in their course; that the same vein is sometimes contracted and sometimes dilated; that veins are frequently terminated by being split or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fissures are always widest at top and are very narrow below: all which appearances, he thinks, could not have been produced by exsiccation. From these reasons, fissures appear to have had a different, and from the direction and rupture of veins

crossed by fissures, they seem to have had a later origin than veins. Whether fissures could have been produced by the very gradual exsiccation of these large masses of strongly coherent matter; or whether they have been produced by the same violent causes, namely, earthquakes, by which the strata in which fissures are generally found have been broken and deranged, and by which metalliferous mountains themselves have been formed, or their strata raised above their original level; as some authors have, with great probability, conjectured; I do not pretend to determine.

Veins are seldom, if ever, found but in mountains. The reason of which may not improbably be, that in metalliferous mountains we have access to the more ancient strata of the earth, which in plains are covered with so many deposited, alluvial, and other later strata, that we can seldom, if ever, reach the former. That these mountains consist of strata which have been originally lower than the upper strata of adjacent plains, appears from an observation which has been made, that the strata of mountainous countries dip with more or less declivity as they approach the plains, till they gradually sink under the several strata of those plains, and are at last immersed beyond the reach of miners. This leading fact in the natural history of the earth has been observed by a sagacious philosopher, Mr. Mitchell, in his *Conjectures concerning Earthquakes, &c. Philos. Transf.* 1760.

That the inferior strata of the earth contain large quantities of pyritous, sulphureous, and metalliferous matters, appears, 1. From the subterranean fires in those inferior strata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniously conjectures). 2. From the observation, that all kinds of mountains are not equally metalliferous; but that veins, especially, are only found in those mountains, which, being composed of very ancient strata, are called *primæval*, which form the chains and extensive ridges on the surface of the earth, which direct the course of the waters, and which consist of certain strata, the

The gold which is found alone is called *native* or *virgin gold*. This is generally incrustated, and fixed in different kinds of stones, principally in flints

the thickness of each of which, its generic qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and therefore that veins are seldom, if ever, found in the mountains called by authors *diluvial* and *temporary*, which are single, or detached, which consist not of strata uniformly disposed, but of alluvial masses, in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjointed. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuable to miners than the veins in lofty, craggy, irregular, and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing, that they have been gradually formed from all times, and are now daily, formed. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and striae in the hardest stones, we are inclined to believe, that the matter of these veins and nodules are coeval with the rocks and stones in which they are enveloped. Nevertheless, we cannot doubt that small quantities, at least, of ores are still daily formed in veins, fissures, and other subterranean cavities. Several well attested

instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver-ore that was found adhering to a thin coat of lamp-black, or of soot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg in Norway; and that this incrustation of silver-ore had been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver-ore attached to the step of a ladder, found in a mine in Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly encrusted had been found. Many other instances are mentioned by authors, of galena, pyrites, silver-ores, and other metalliferous substances, having been found adhering to wood, to fossil-coal, to stalactitical encrustations, to oyster-shells, and other recent substances. From these, and from similar instances which I have seen, I am induced to believe, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralised ores are recently formed; although many histories mentioned by Becher, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralised ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called *Gubra*. See *GUHR*. Other authors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapors, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapor condense, and become in a few days changed into gold, silver, and other metallic matters: but the existence of such vapors is not ascertained; for the noxious vapors commonly supposed to be sulphureous, arsenical, and metalline, are nothing but the permanently elastic vapors called *inflammable* and *uninflammable fixable airs*. See *DAMPS*.

Whether the component parts of ores have been once reduced to a state of vapor, and

and quartz. Mr. Cramer says, that the yellow brilliant spots of the blue stone, called *lapis lazuli*, are native gold; but these are very small. (c)

Gold is also found in fat and muddy earths; and Mr. Cramer affirms, that scarcely any sand can be found which does not contain gold; but he acknowledges, at the same time, that the quantity is too small to compensate for the expence of obtaining it.

Lastly, the largest quantity of native gold is to be found in the sands of some rivers. It is chiefly collected in hollows at the bottom of these rivers, and at their several bendings. The gold is collected in these places by a natural operation, similar to that of washing of ores.

A considerable quantity of gold is in the sand of several rivers in France; so that persons who collect it find enough to compensate their trouble. Mr. Reaumur, in a Memoir that he gave in the year 1718 concerning the Rivers of France which contain gold, enumerates ten of them, namely, the Rhine, the Rhone, the Doux, the Ceze, and the Gardon, the Arriege, the Garonne, two streams which flow into the Arriege, called Ferriet and Benagues; lastly, the Salat, the source of which is in the Pyrenean mountains.

The Ceze is the river which furnishes the largest quantity of gold at certain times. Mr. Reaumur observes, that its particles are larger than those of the Rhine and of the Rhone, and says, that in some days a peasant will find gold to the value of a pistole, and in others will scarcely find any.

and in that state have been united; or whether these parts were conveyed to veins already combined, but in a fluid state; or by what natural process they have been brought together and united, we have not sufficient data to investigate and determine.

We can indeed by analysis discover what these component parts of ores are; and we can even imitate many ores by fusing together those parts: but, from the regularity of the forms and structures of ores, the union of their component parts must have been accomplished by a more gradual process; and, although it be difficult to explain how ores could be dissolved in a watery menstruum, and afterwards crystallized, so as to form the regular masses which they now constitute; yet when we consider how many solutions and decompositions are effected by the very slow and gradual operations of nature, which cannot be effected by those of art, the conjecture (if, in a subject so obscure, and concerning which neither sufficient facts have been discovered, nor is the life of man sufficiently long to make observations and experiments, conjectures may be admitted) seems not improbable that ores, and perhaps all other mineral crystallized matters, as spars, crystals, fluors, &c. have been once

dissolved in an aqueous menstruum, by evaporation of which they have been afterwards concreted and crystallized. An instance of the formation of silver-ore from a metalliferous water has already been quoted from a Memoir in the Swed. Act. by Mr. Cronstedt. The liquors called *gubbs*, found in mines, are known to contain frequently, besides metallic matters, also calcareous and gypseous particles. By intervention of these earthy matters, may not also sulphur be dissolved in water, and thus a hepar, the most powerful solvent of metallic substances, be formed? If we suppose such a hepar impregnated with metallic particles to be collected in a subterranean cavity, where the water might be exceedingly slowly evaporated, till no more remained than was sufficient for the crystallization of the solid matters, might not these matters then separate and crystallize distinctly, the earthy substances first concreting, and forming spars, fluors, and other matrixes, which would adhere to the solid rock, while the sulphureous, arsenical, and metallic substances should afterwards concrete together, and compose ores which would adhere to the matrixes previously formed?

(c) Concerning these, see LAPIS LAZULI.

The native gold found in rivers or elsewhere is never perfectly pure, or of twenty-four karats. It always contains a certain quantity of allay, which is generally silver. The gold of our rivers, according to Mr. Reaumur's trials, was found to be from eighteen to twenty-two karats, that of the Ceze being the lowest, and that of the Arriège being the purest. (d).

**DXI. ORES of PLATINA.** Platina is very rare, and has been but lately discovered. As, like gold, it cannot be allayed with sulphur or with arsenic, probably no ore properly so called exists of this metal. Accordingly,

(d) **ORES of GOLD.** Although gold cannot be directly dissolved by sulphur, yet it probably may be mineralised by the intervention of other metallic matters. Thus, although no proper ore of gold exists, yet it is found in several mineral substances, in which it is always accompanied, as Cramer affirms, with a much larger quantity of silver; to which latter metal that author attributes its mineralised state. The minerals containing gold are blend, cupreous and arsenical pyrites, ore of antimony, cinnabar, white ore of arsenic, vitreous and other silver ores, and the lead-ore called galena.

Gold is more frequently imbedded in quartz than in any other matrix, but it is also found in limestone and in hornblend. Gold mines are in general very precarious, as they do not form regular veins, nor is the gold uniformly distributed through a matrix.

Becher and Cramer think, that no sand is entirely free from gold. The yellow, red, black, and violet-colored ferruginous, are said to contain most gold. Mr. Hellot relates, that in eleven essays of one kind of sand, from a quintal, or 921600 grains, were obtained each time from 848 to 844 grains of noble metal, exclusive of the gold which remained in the scoria; and that of the metal thus obtained two thirds were gold, and the remaining third was silver. He says, that parcels of sand taken up at very small distances from each other contained very unequal proportions of gold.

The gold found in sands is generally less pure than that which is imbedded in a solid matrix. Reaumur says, that a piece of gold, weighing 448 ounces, was shown to the Royal Academy at Paris, which was found upon essay to have different fineness in different parts of the mass.

Ores and earths containing gold may be assayed by the methods directed for the extraction

of gold from large quantities of these auriferous matters (*see SMELTING of ORES*): or they may in general be assayed by being fused in a cupel or test, placed under the muffle of an assay-furnace, or in a crucible placed in an air-furnace, with eight or ten times their quantity of lead, if they be fusible; and with a larger quantity of lead, if they be difficultly fusible; and by scorifying the earthy matters, while the lead becomes impregnated with the noble metals. These operations are entirely similar to those employed for the separation of silver from its ores by precipitation with lead; a detail of which see subjoined under the article **ORES of SILVER**, in a Note [Processes I. III. IV. V. VI]. These metals are afterwards to be separated from the lead by cupellation, in the manner directed in the articles, **ESSAYS of the VALUE of SILVER, and of GOLD**. The gold is then to be separated from the silver by the processes described in the article **PARTING**.

The quantity of lead to be added to the ore in this assay must be such as renders the scoria very thin, that the whole gold may be imbibed by the lead. Some iron-ores containing gold cannot be reduced into a scoria sufficiently thin with sixteen times their quantity of lead, unless the heat be, at the same time, considerably increased. When the ore is exceedingly refractory, the scorification ought to be promoted by adding to it four times its quantity of tartar, twice its quantity of nitre, and four times its quantity of litharge. This mixture is to be put in a good assay-crucible, and covered with sea-salt. The crucible is to be set in a forge-hearth, and exposed gradually to heat, till the scoria has acquired sufficient fluidity, and the lead has imbibed the noble metal.

See the methods which have been used for assaying auriferous sands, under the article **SMELTING of ORES**.

in the only mines of platina which we know, namely, the gold mines of Santafe near Carthagena, the platina is found native like the gold, and in its metallic state.

**DXII. ORES of SILVER.** Next to gold, silver is the metal most frequently found in its metallic state, that is, not mineralised by sulphur or by arsenic. This silver, called also *native* or *virgin*, generally affects some regular form, and consists of filaments or vegetations of various figures. Native silver, like gold, is incrustated, or adherent to several kinds of stones. It is generally alloyed with some gold: but silver, like all the other metals, is much more frequently found mineralised by sulphur and by arsenic. (e)

Three principal proper ores of silver are known, which are very rich, but were rare. These are;

1. The *vitreous silver ore*. This ore has no determinate figure, and has nearly the color, softness, and fusibility of lead. It is very heavy, and contains three quarters of its weight of pure silver. In this ore the silver is mineralised by sulphur alone. Some expert artists imitate it very well by combining sulphur with silver by fusion in a crucible. (f)

2. The *horny or corneous silver ore*. This ore is so called from its color and semitransparency, by which it resembles horn or colophony. This ore, being suddenly heated, crackles, as almost all ores do, and melts with a gentle heat. Two-thirds of it are silver, which is mineralised by sulphur and arsenic. This ore is very rare. Wallerius says, after Woodward, that it is found at *Johann-Georgen-Stadt* in *Saxony*. (g)

3. *Red silver ore*, called also *Rosiclar*. Its color is more or less red; it is sometimes crystallized, very heavy, and is fusible like the above-mentioned ores. In this ore the silver is mineralised by arsenic and by sulphur, but chiefly by the former. It also contains a little iron, and furnishes two-thirds of its weight of silver. Its red color may proceed either from the iron it contains, or from the mixture of arsenic and sulphur, or, lastly, from the particular manner in which the arsenic is united with the silver, an example of which we

(e) **ORES of SILVER.** *Native silver* is found in form of plates, of fibres, or of grains, or crystallized. It lies generally in quartz, flint, spar, slate, cobalt, and in silver-ores. It is sometimes enveloped in a thin stony crust.

(f) The *vitreous ore*, according to Cronstedt, is either in form of plates or of fibres, or is crystallized, or has no determinate figure. It may be imitated by adding about five parts of sulphur to one part of melted silver; in which operation most of the sulphur is consumed: or it may be imitated by exposing a plate of silver red-hot to the fumes of burning sulphur.

(g) *Corneous ore* has various colors; white, pearly, brown, yellow, greenish, or reddish. It is foliated and semitransparent. It is somewhat ductile, and fusible with the flame of a candle. When heated, it emits, as Wallerius

says, a sulphureous and blue flame, and, according to Cramer, also a very small quantity of an arsenical fume. Wallerius says, that it contains two-thirds of silver, with a considerable quantity of sulphur and a small quantity of arsenic. Lehman thinks, that it is silver united with a little arsenic. But Mr. Cronstedt says, that it is a luna cornea, or silver combined with marine acid; and that it is incapable of being decomposed but by substances which can unite with that acid. This latter opinion seems to be the most probable, as the ore, according to its description, is similar to luna cornea, and as it cannot be imitated by any mixture of sulphur and of arsenic with silver. The blue flame, and the smell slightly arsenical, which are emitted from heated corneous ore, are also observable from every combination of marine acid with a substance containing phlogiston.

have

have in the red precipitate of silver made by the neutral arsenical salt. See ARSENIC and SALT (NEUTRAL ARSENICAL). (b)

Besides these, many other minerals are called silver ores, but which are only improper ores of silver as they contain a larger quantity of some other metal (i).

(b) *Red silver ore* is either plated or solid, or crystallized, and frequently semitransparent. Its color is various, from a dark grey to a deep red, according to the proportions of the two mineralizing substances. It crackles and breaks in the fire, exhales an arsenical fume, and is readily fused. It is found generally in quartz, spar, crystal, hornblend.

(i) Besides the three silver-ores above described, the following ores contain silver mixed with other metals.

1. *Grey silver ore*. This contains copper and silver mineralized by arsenic and sulphur, and generally more of the former than of the latter metal; but as it is valued chiefly for the silver, it has been generally enumerated amongst silver ores.

2. *White silver ore* is an arsenical pyrites containing silver.

3. *Black silver ore* contains sulphur, arsenic, copper, iron, sometimes lead, and about a fourth part of silver, according to Wallerius.

4. *Plumose silver ore* is white or black, striated like plume-alum, or like ore of antimony. It is silver mineralized by sulphur, arsenic, and antimony.

5. *Pech-blend*. In this blend silver, gold, and zinc, are mineralized by sulphur, probably by intervention of iron, by which the gold and zinc are rendered capable of uniting with the sulphur.

6. Silver is frequently found in *galena*; and sometimes in *martial pyrites*; in the *red ore of arsenic*; in various ores of copper, lead, tin, iron, and especially cobalt; in blends; in yellow or red earths; in black and blue basaltes; and also in strata of stones, which do not appear externally to contain any mineral substance.

7. *Liquid silver ore*, or *guhr of silver*, is a grey or whitish liquid mass which contains, as Wallerius says, either native silver, or some fluid substance capable of producing it. Mr. Cronstedt mentions, in the Swedish Memoirs, a water flowing through a mine in Norway containing silver. Another instance is also mentioned of a silver guhr, in the Act. Erud. Upsal. 1720.

8. Mr. Von Justi pretends, that he has

found silver mineralized by an *alkaline substance*; but he has not spoken sufficiently distinctly concerning it, to know whether he means a saline or earthy alkaline matter. Henkel also pretends, that by treating calcareous earth or certain clays with pyrites, silver may be obtained.

*Ores of silver may be assayed* [See the article ESSAY of ORES] by the same methods which are employed for the extraction of that metal from large quantities of ores; which methods are different, and suited to the different qualities of the several ores. See SMELTING of ORES. Or, in general, ores and earths containing silver may be assayed by the following Processes, which are copied from Dr. Mortimer's English edition of Cramer's Art of Assaying Metals, Part II. Processes 1.

## PROCESS I.

*To precipitate Silver by means of Lead from fusible Ores.*

“ POUND the ore in a very clean iron-mortar into fine powder: of this weigh one docimaistical centner or quintal, and eight of the like centners of granulated lead.

“ Then have at hand the docimaistical test (see PLATE I.), which must not as yet have served to any operation: pour into it about half of the granulated lead, and spread it with your finger through the cavity of it.

“ Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

“ Put the test thus loaded under the muffle of an assay-furnace, and in the hinder part of it: then make your fire, and encrease it gradually. If you look thro' the holes of either of the sliders, you will soon see that the pounded ore will be raised out of the melted lead, and swim upon it. A little after, it will grow clammy, melt, and be thrown towards the border of the test: then the surface of the lead will appear in the middle of the test like a bright disc, and you will see it smok and boil: so soon as you see this, “ it

Such are the *blue silver-ore*, which is only a lead-ore containing much silver, and the *grey silver-ore*, which is a copper-ore containing silver.

“ it will be proper to diminish the fire a small matter for a quarter of an hour ; so as that the boiling of the lead may almost cease. Then again, encrease the fire to such a degree, that all may turn into a thin fluid, and the lead may be seen, as before, smoaking and boiling with great violence. The surface of it will then diminish by degrees, and be covered over with a mass of scorias. Finally, have at hand an iron hook ready heated, where- with the whole mass must be stirred, especially towards the border ; that in case any small parcels of the ore not yet dissolved should be adherent there, they may be brought down, taking great care not to stir any the least thing out of the test.

“ Now, if what is adherent to the hook during the stirring, when you raise it above the test, melts quickly again, and the extremity of the hook grown cold is covered with a thin, smooth, shining crust ; it is a sign that the scorification is perfect ; and it will be the more so as the said crust adherent to the hook shall be colored equally on every side : but in case, while the scorias are stirred, you perceive any considerable clamminess in them, and when they adhere in good quantity to the hook, though red-hot, and are inequally tinged, and seem dusty or rough with grains interspersed here and there ; it is a sign that the ore is not entirely turned into scorias. In this case, you must with a hammer strike off what is adherent to the hook, pulverize it, and with a ladle put it again into the test, without any loss or mixture of any foreign body, and continue the fire in the same degree till the scoria has acquired its perfection, and the above-mentioned qualities. This once obtained, take the rest with a pair of tongs out of the fire, and pour the lead, together with the scoria swimming upon it, into a cone made hot and rubbed with tallow. Thus will the first operation of the process be performed, which does not commonly indeed last above three quarters of an hour.

“ With a hammer strike the scorias off from the regulus grown cold, and again

“ examine whether they have the characteristics of a perfect scorification ; if they have, you may thence conclude, that the silver has been precipitated out of the ore turned to scorias, and received by the lead,

“ When the scorification lasts longer than we mentioned, the lead at last turns to scorias or litharge, and the silver remains at the bottom of the vessel : but the fire must be moderately supplied, and the vessels be extremely good, to produce this effect ; for they seldom resist to the strength of the scorias long enough ; so that the whole scorification may be brought to an end ; which has afterwards this inconvenience, that the silver is dissipated by grains in the small hollows of the corroded ore, and can hardly be well collected again, when the ore has but little silver in it. Nay, there is still more time to be consumed to obtain the perfect destruction of the lead, by means of the combined actions of the fire and air, because the scorias swimming at the top retard it considerably.

“ In this process, the sulphur and the arsenic of the silver-ore, when the ore is broken small, and extended widely in a small quantity, are in part easily dissipated by the fire, and in part absorbed by the lead ; the lighter part of which, swimming upon the heavier, becomes very clammy by means of the sulphur which is in the ore ; but when this is dissipated by the violence of fire, it turns into glass or scorias : but when arsenic is predominant in the ore, the plumbeous part turns immediately into a very penetrating and very fusible glass, having a dissolving efficacy, unless the arsenic lies hidden in a white pyrite or cobalt. For this reason, the fixed part of the ore, which is no silver, is dissolved by that glass, melts, and assumes the form of scorias. The unmetallic earths and the pure copper or lead-ores thereto adherent are of this kind. The silver then remains immutable, and being freed of these heterogeneous bodies, which are partly dissipated and partly melted, it is precipitated and received by the remain-

“ ing

# DXIII. O R E S of C O P P E R. Copper is found under ground

“ing regulus of lead. Therefore this process is completed by three distinct operations; viz. 1. By roasting. 2. By scorification. 3. By the melting precipitation of the silver, which is the result of the two former operations.

“The ore must be pulverised very fine in order to encrease the surface, that the dissipation of the volatiles and the dissolution by litharge may be sooner effected. This pulverising must then be done before the ore is weighed, because there is always some part of the ore adherent to the mortar or iron-plate on which it is made fine; which part being lost, the operation is not exact. *Erker* was in the right when he prescribed eight centners of lead for the subduing of fusible ores. Nevertheless, it must be owned that this quantity is superfluous in some cases. However, as the fluxibility of the silver-ore depends from the absence of stones, pyrites, &c. it is easy to see, that there are an infinite number of degrees of fluxibility which it would be needless to determine exactly, and most commonly very difficult to determine by the bare sight. Besides, a little more lead does not render the process imperfect; on the contrary, if you use too small a quantity of lead, the scorification is never completely made. Nay, there are a great many ores, containing sulphur and arsenic in plenty, that destroy a considerable quantity of lead: such are the red silver-ore, and that wherein there is a great deal of the steel-grained lead ore. If the fire must be sometimes diminished in the middle of the process, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead; from penetrating the pores of the test, and from corroding it; which is easily done when the fire is over-strong; for then the surface of the vessel which is contiguous to the lead contracts cavities, or being totally consumed by small holes, lets the regulus flow out of it. The vessels that are most subject to this inconvenience are those in the materials of which lime, plaster, and chalk are mixed. Nay, these bodies, which are of their nature refractory, being eroded during their scori-

“fication, at the same time, communicate a great clamminess to the scoria; so that a great quantity of the mass remains adherent to the test in the form of protuberances, when you pour it out; whereby a great many grains of the regulus are detained.”

## P R O C E S S II.

THE regulus obtained by the process I. contains all the silver of the ore, and the unscorified part of the lead. The silver may be afterwards separated from the lead, and obtained pure by *cupellation*; which process is described under the article of the Dictionary, ESSAY of the VALUE of SILVER.

## P R O C E S S III.

*IF the silver-ore cannot be washed clean, or if it be rendered refractory by a mixture of unmetallic earths and stones, the scorification of these earthy matters frequently cannot be completed by the process I. Cramer therefore directs that such ores shall be treated in the following manner [Art of Assaying, Part II. Process 3].*

“Bruise the ore into an impalpable powder, by grinding in a mortar; to a docimastical centner of it, add a like quantity of glass of lead finely pulverised; for the more exactly these two are mixed together, the more easily the scorification afterwards succeeds. Put this mixture, together with twelve centners of lead, into the test, according to process I. then put the test under the muffle.

“Make first under it a strong fire, till the lead boils very well; when you see it so, diminish the violence of the heat, as was directed in the first process; but keep it thus diminished a little longer: then, finally, again encrease the fire to such a degree, till you perceive the signs of a perfect scorification and fusion. See the whole Process I. Now this process lasts a little longer than the foregoing, and requires a greater fire towards the end.

“It sometimes happens that a very refractory ore cannot be dissolved by litharge; and that a mass, which has the clamminess of



in three different forms. 1. Native or virgin copper diversely ramified, which

“ of pitch, swims upon the regulus and upon  
 “ the scorias themselves which are already  
 “ subdued in part: when you see this, shut  
 “ the vents of the furnace to diminish the  
 “ fire; then gently touch this refractory body  
 “ with a small iron cold hook, to which it  
 “ will immediately stick; take it off softly,  
 “ not to lose any thing; pound it into a fine  
 “ powder, adding a little glass of lead; and  
 “ put it again into the test; then continue  
 “ the scorification, till it is brought  
 “ to its perfection. But you must always  
 “ examine the scoria of your refractory ore,  
 “ to see whether there may not be some  
 “ grains of regulus dispersed in it; for some-  
 “ times the scorias that grow clammy retain  
 “ something of the metal; which if you  
 “ suspect, pound the scoria into a fine dust,  
 “ and thus the grains of metal will appear,  
 “ if there are any left; because they can  
 “ never be pounded fine. The silver is sepa-  
 “ rated from this regulus by coppelling, as  
 “ in Process II.

“ All earths and stones are refractory in  
 “ the fire; for, although some of them melt  
 “ naturally in the fire, as those that are  
 “ vitrifiable do; nevertheless, all the others,  
 “ a very few excepted, melt much more dif-  
 “ ficultly than metals, and never become  
 “ so thin in the fusion as is required for  
 “ the sufficient precipitation of a precious  
 “ metal. But litharge itself does not con-  
 “ veniently dissolve these refractory matters  
 “ by the help of fire alone, unless you add  
 “ some mechanical mixture to them; for  
 “ the very moment the said litharge pene-  
 “ trates through the interstices of the refrac-  
 “ tory ore, and begins to dissolve it, a tena-  
 “ cious mass is produced, which hardly  
 “ admits any farther dilution by the litharge.  
 “ You may see it plain, if you make colored  
 “ glasses with metallic calxes; if you pour  
 “ carelessly upon them a calx that gives a  
 “ color, you will never obtain that they may  
 “ be equally died on every side, even altho’  
 “ you should torture them for whole days  
 “ together in a great fire. Nay, glass already  
 “ made can never be diluted by only pouring  
 “ salts and litharge upon it. Wherefore,  
 “ you must use the artifice of glass-makers,  
 “ who in the making of the most perfect  
 “ glasses, take great care before they put the  
 “ species of their ingredients into the fire, to

have a mechanical mixture precede, or at  
 least accede during the fusion itself; which  
 is done here by pounding glass of lead  
 mixt with the ore: but if you think that  
 your glass of lead is not sufficiently fusible,  
 you may add to it litharge melted first, and  
 then pounded into a fine powder.

“ As this scorification requires a longer  
 and a greater fire than the foregoing, and  
 as a greater quantity of litharge is more-  
 over requisite to subdue the refractory  
 scoria; it is easy to see why a much  
 greater quantity of lead must be used here  
 than in Process I. and, although less lead  
 is often sufficient, it is nevertheless proper  
 always to use the greatest quantity that  
 can be necessary, lest, for instance, it  
 should be necessary to try so many times  
 the lead alone, to make it evident how  
 much silver the lead when alone leaves in  
 the coppel. Nor need you fear lest any  
 thing of the silver be taken away by the  
 lead, provided the coppels be good, and  
 the coppelling duly put in execution: for  
 you can hardly collect a ponderable quan-  
 tity of silver out of the collected fume of  
 the lead, which rises during the coppelling,  
 as well as out of the litharge, that is with-  
 drawn into the coppel.”

#### P R O C E S S IV.

*IF the ore be rendered refractory by pyrites,*  
 Cramer directs, that the silver should be  
 precipitated by lead in the following manner.  
 [*Art of Assaying, Part II. Proc. 4.*]

“ Break your ore into a rough powder,  
 “ and put a centner of it into the test: put  
 “ upon this another test in the manner of a  
 “ tile; put it under the muffle hardly red-  
 “ hot: increase the fire by degrees. There  
 “ will always be a crackling: which being  
 “ ended, take away the upper test; for when  
 “ the vessels have been red-hot about one  
 “ minute, the ore ceases to split. Leave the  
 “ ore under the muffle till the arsenic and  
 “ the sulphur are for the most part eva-  
 “ porated; which you will know from the  
 “ cessation of the visible smok, of the smell  
 “ of garlic, or the acid; then take away the  
 “ test, and leave it in a place not too cold,  
 “ that it may cool of itself.

“ Pour out, without any dissipation, the  
 “ roasted

is much more rare than native silver. This native copper is not so ductile as

“ roasted ore, and with a knife take away what is adherent to the vessel; pound it to a most subtle powder, and grind it together with an equal weight of glass of lead; and, finally, scorify the whole collected ore in the same test wherein the testing was made, unless it has contracted chinks, as was described in Process III.

“ *Remarks.* Yellow pyrites-ores contain a very great quantity of sulphur, even greater than is necessary to saturate the metal that lies hidden in them. For which reason this superfluous sulphur dissipates in a middling fire; but if it had been mixed with lead it would have rendered it refractory, nor could it afterwards be dissipated from it without a considerable destruction of the lead. The white arsenical pyrites turn also a great quantity of lead into glass, on account of the abundance of the arsenic they contain. For which reason these ores must be previously roasted, that the sulphur and arsenic may be dissipated. Nor need you fear lest any part of the silver be carried away with the arsenic; for when arsenic is separated from any fixed body, by a certain degree of fire, it carries nothing of that body away with it.”

### P R O C E S S V.

*SILVER may be precipitated from its ore by cupellation only, in the following Process, given by Cramer. [Art of Assaying, Part II. Proc. 9.]*

“ Pound one centner of ore; roast it in the manner directed in the last process; beat it to a most subtle powder; and if it melts with difficulty on the fire, grind it together with one centner of litharge, which is not necessary when the ore melts easily: then divide the mixture or the powder of the ore alone into five or six parts, and wrap up every one of them severally in such bits of paper as can contain no more than this small portion.

“ Put a very large coppel under the muffle; roast it well first, and then put into it sixteen centners of lead: when the lead begins to smok and boil, put upon it one of the said portions with the small paper it was wrapt up in, and diminish

“ the fire immediately, in the same manner as if you would make a scorification in a test, but in a lesser time. The small paper, which turns presently to ashes, goes off of itself, and does not sensibly encrease the mass of the scorias. The ore proceeding therefrom is cast on the border, and turns to scorias very soon. Increase the fire again immediately, and, at the same time, put another portion of the ore into the coppel, as was just now said. The same effects will be produced. Go on in the same manner, till all the portions are thrown in and consumed in the lead. Finally, destroy the remaining lead with a stronger fire.

“ The silver that was in the ore and in the lead will remain in the coppel. If you deduct from it the bead proceeding from the lead, you will have the weight of the silver contained in the ore. If the ore employed was easy to be melted, all the scoria vanishes; but if it was refractory or not fusible, all the scoria does not always go away, but there remains something of it now and then in the form of dust. A great many ores and metals may be tried in this way, except only such as split and corrode the coppels. There are likewise some of them which must be previously prepared, in the same manner as is required, to render them fit for going through a scorification. See the foregoing Processes.

“ *Remarks.* The ore thrown at several times upon lead boiling in a coppel may be dissolved without the foregoing scorification: but this is very far from having an equal success with all kinds of ores; for there are ores and metals which resist very much to their dissolution by litharge; and which being on this account thrown on the border, are not sufficiently dissolved; because the litharge steals away soon into the coppel. Nevertheless, there are some others which vanish entirely by this method, except the silver and gold that was contained in them.

“ A previous roasting is necessary, first, for the reasons mentioned, and then because the ore thrown upon boiling lead should not crackle and leap out; for, having once passed the fire, it bears the most sudden heat.”

as copper purified by fusions from the ore (*k*). 2. Copper is found in form of calx, of verdigrease, of precipitates. Such are the minerals called silky copper ores, and several white and green earths. These matters are only copper almost pure and but little mineralised, but which has been corroded, dissolved, precipitated, calcined by saline matters, by the action of the air, of water, and of earths (*l*). 3. Copper is frequently in a truly mineral state, that is,

#### PROCESS VI.

“Silver may be precipitated out of the same  
“bodies as were mentioned in the foregoing  
“processes by scorification in a crucible.  
“[Cramer, Proc. xv.]

“THE body out of which you intend to  
“precipitate silver must be previously prepared for a scorification by pounding and roasting, as mentioned in the former processes. Then in the same manner, and with the same quantity of lead, put it into a crucible strictly examined, that it be entire, solid, not speckled with black spots, like the scoria of iron, especially at its inferior parts, and capable of containing three times as much. Add besides glass gall and common salt, both very dry, and enough, that when the whole is melted, the salts may swim at top at the height of about half an inch.

“Put the crucible thus loaded into a wind-furnace; shut it close with a tile; put coals round it, but not higher than the upper border of the crucible. Then light them with burning coals, and increase the fire till the whole melts very thin, which will be done by a middling fire, maintained always equal, and never greater: leave it thus for about one quarter of an hour, that the scorification may be perfectly made. Take off the tile and stir the mass with an iron wire, and a little after pour it out into the mould. When the regulus is cleaned from scorias, try it in a test by coppelling it.

“Remarks. The scorification of any ore whatever, or of any body fetched out of ores, may indeed be made by this apparatus, as well as in a test under a muffle: but it serves chiefly to the end that a greater quantity of metal may be melted from it with profit. For you may put many common pounds of it at one single time into the crucible; but then you need not observe the proportion of lead prescribed in the foregoing process; nay, a

“quantity of lead two or three times less is sufficient, according to the different qualities of the object. But the mass will certainly be spilt, unless you chuse a very good crucible; for there is no vessel charged with litharge, that can bear a strong fire having a draught of wind, without giving way through it to the litharge.

“You add glass-gall and common salt, that they may forward the scorification, by swimming at top; for the refractory scoria rejected by the litharge, and adhering between this and the salts, that swim at top; is soon brought to a flux; and the precipitation of the silver is thereby accelerated. They also hinder in a manner a small burning coal fallen into the crucible, from setting the litharge a boiling, which troubles the operation; for the litharge or glass of lead, especially that which is made without any addition, so soon as the phlogiston gets into it, raises into a foamy mass, consisting of a multitude of small bubbles very difficult to be confined, unless the phlogiston be entirely consumed, and the litharge reduced to lead, which sometimes rises above the border of the vessel.”

*Native metallic silver* may be separated from the stones and earths with which it is intermixed, by *amalgamation with mercury*, which operation is to be performed in the same manner as for the separation of native gold; a detail of which see at the article SMELTING OF ORES.

The *corneous ore*, if it really be, as Cronstedt says, a luna cornea, ought to be treated in some of the methods directed for the reduction of luna cornea. See LUNA CORNEA.

(*k*) **COPPER ORES.** *Native Copper* is solid; or consisting of friable masses, formed by precipitation of cupreous vitriolic waters, called *cement*, or *ziment copper*; or forming crystallized cubes, or grains, leaves, branches, or filaments.

(*l*) *Calxiform ores* are either pure calxes of copper, or are mixed with heterogeneous matters. 1. The *pure* are loose friable ochre,

combined with sulphur, and with arsenic, with other metallic matters mixed with earths, and enveloped in different matrixes. These are the true copper ores. They have no regular forms except they partake of the nature of pyrites. Their colors are very different, which depend chiefly on the proportion of the mineral substances composing them. Lastly, in almost all of them we may perceive green or blue colors, which always indicate an erosion or calcination of the copper. Most copper ores contain also some iron or ferruginous earth, to which the ochrey color is to be attributed, which might make us believe them to be ores of iron. Ores which contain much iron are the most difficultly fusible.

Copper ores have almost all a yellow, golden, and shining color, by which they are easily distinguished. Some of them are colored with irides, and frequently have spots of verdegriſe, by which also they are distinguishable from other ores. (m)

ochre, called *ceruleum montanum*, mountain blue, and *viride montanum*, mountain-green; and the *red indurated calx*, called improperly *glass copper ore*. 2. *Mixed calciform ores* are those in which the calx of copper is mixed; with *calcareous earth*, forming a mountain blue; with *iron*, forming a black calx; with *gypsum*, an indurated green ore, called *malachites*; and with *quartz*, a red ore.

(m) Copper is mineralised, 1. By *sulphur*, forming the *grey copper ore*, improperly called *vitreous* (minera cupri vitrea Wallerii). 2. By *sulphurated iron*, forming the *hepatic copper ore* (minera cupri hepatica Wallerii) of a brown yellow color. It is a kind of cupreous pyrites, and is called by Cronstedt *minera cupri pyritacea*. Sometimes it is of a blackish grey color, and is then called *pyrites cupri griseus* (minera cupri grisea Wallerii); sometimes of a reddish yellow, and tarnished with blue irides on its surface, when it is called *minera cupri la-urea*; when of a yellowish-green color, it is the *pyrites cupri flavo viridescens* cuprum sulphure & ferro mineralisatum Wallerii; and when of a pale-yellow color, it is the *pyrites cupri pallidus fœvus*. Most of the above pyritaceous ores contain also some arsenic, but their sulphur is predominant. 3. *Copper mineralised by sulphur, iron, and arsenic*. *White copper-ore* (Minera cupri alba Wall.). This ore contains also some silver. 4. *Copper dissolved by vitriolic acid*. *Native blue vitriol*. 5. *Copper united with bitumens*. *Copper coal-ore*. This is a pitcoal from the ashes of which copper is obtainable. 6. Copper is also found in the mineral called *kupfer-nickel*.

*Ores of copper may be essayed in methods similar to those employed for smelting of large quantities of ores (see SMELTING OF ORES); or they may in general be essayed by the following processes.*

## PROCESS I.

[Extracted from Cramer's *Art of Assaying*, Proc. 35.]

“ To reduce and precipitate copper from a pure  
“ and fusible ore in a close vessel.”

“ MIX one, or, if you have small weights,  
“ two do. imaitical centners of ore beat ex-  
“ tremely fine, with six centners of the black  
“ flux; and having put them into a crucible  
“ or pot, cover them one inch high with  
“ common salt, and press them down with  
“ your finger: but let the capacity of the  
“ vessel be such, that it may be only half  
“ full; shut the vessel close; put it into  
“ the furnace; heap coals upon it so that  
“ it may be covered over with them a few  
“ inches high; govern the fire in such a  
“ manner, that it may first grow slightly  
“ red-hot. Soon after you will hear your  
“ common salt crackle; and then there will  
“ be a gentle hissing noise. So long as this  
“ lasts, keep the same degree of fire till it  
“ is quite over. Then encrease suddenly  
“ the fire, either with the funnel and cover  
“ put upon the furnace, or with a pair of  
“ bellows applied to the hole of the bot-  
“ tom part, that the vessel may grow very  
“ red-hot. Thus you will reduce and pre-  
“ cipitate your copper in about a quarter  
“ of

Many copper ores are also rich in silver. Such is that called the white copper ore, the color of which is rather occasioned by arsenic than by silver, al-

"of an hour: then take out the vessel, and strike with a few blows the pavement upon which you put it, that all the small grains of copper may be collected in one mass.

"Break the vessel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole process has been well performed, you will find a solid, perfectly yellow and malleable regulus adhering to the bottom of the vessel, with scorias remaining at top of a brown color, solid, hard, and shining, from which the regulus must be separated with several gentle blows of a hammer; this done, weigh it, after having wiped off all the filthiness.

"A soft dusty and very black scoria is a sign of a fire not sufficiently strong. Small neat grains of copper reduced but not precipitated, and adhering still to scorias, especially not very far from the bottom, and an unequal and ramificated regulus, are signs of the same thing. A solid, hard, shining, red-colored scoria, especially about the regulus, or even the regulus itself when covered with a like small crust, are signs of an excess in the degree and duration of the fire.

"Remarks. All the ores which are easily melted in the fire are the objects of this process; for they must also be very pure. Such are the vitreous copper ores."

[Mr. Cramer means, I presume, the red calciform ore called improperly *glass ore*, and not the *minera cupri vitrea* of Wallerius, which being composed of copper mineralised by sulphur, could not be treated properly by this process, in which no previous roasting is required. The sulphur of this ore would with the alkali of the black flux form a hepar, from which the metal would not precipitate,] "but especially the green and azure-colored ores, and the *cæruleum & viride montanum*, which are not very different from them. But if there is a great quantity of arsenic, sulphur, or of the ore of another metal and semi-metal joined to the ore of copper, then, you will never

"obtain a malleable regulus of pure copper, tho' ores are not always rendered refractory by the presence of these."

## PROCESS II.

[Cramer Pr. xxxvii.]

"To reduce and precipitate copper out of ores rendered refractory by earth and stone, that cannot be washed off.

"BEAT your ore into a most subtil powder, of which weigh one or two centners, and mix as much sandiver to them. This done, add four times as much of the black flux with respect to the ore; for by this means, the sterile terrestrial parts are better disposed to a scorification, and the reducing and precipitating flux may act more freely upon the metallie particles freed from all their incumbrances.

"As for the rest, make the apparatus as in last process: but you must make the fire a little stronger for about half an hour together. When the vessel is grown cold and broken, examine the scorias, whether they are as they ought to be. The regulus will be as fine and ductile as the foregoing.

"Remarks. As these copper ores hardly conceal any sulphur and arsenic in them, the roasting would be of no effect, and much copper would be lost. For no metallic calx, except those of gold and silver, improperly so called, can be roasted, without you find a part of the metal lost after the reduction."

## PROCESS III.

"To precipitate copper out of an ore \* that contains iron. [Cramer Proc. xxxviii.]

"DO all according to last process. But you will find after the vessel is broken, a regulus upon no account so fine, but less ductile, wherein the genuine color of the copper does not perfectly appear, and which must be further purified.

\* Mr. Cramer still means the calciform ores only, and not the mineralised ores of copper.

though it contains so much silver as to be enumerated by several mineralogists amongst silver ores.

*Remarks.* The fire used in this operation is not so strong that the iron should turn to a regulus. But as copper is the menstruum of iron, which is of itself very refractory in the fire; for this reason, while the ore and the flux are most intimately mixt and confounded by trituration, the greatest part of the iron being dissolved by the copper, turns into a regulus along with it."

#### PROCESS IV.

[*Cramer Proc. xxxix.*]

*The roasting of a pyritose, sulphureous, arsenical, semi-metallic copper ore.*

"BREAK two docimaetical centners of the ore to a coarse powder, put them into a test covered with a tile, and place them under the muffle of a docimaetical furnace. But the fire must be so gentle, that the muffle may be but faintly red-hot. When the ore has decrepitated, open the test, and continue the fire for a few minutes; then increase it by degrees, that you may see the ore perpetually smoaking a little: in the mean time, it is also proper now and then to stir it up with an iron hook. The shining particles will assume a dark red or blackish color. This done, take out the test, that it may grow cold. If the small grains are not melted, nor strongly adherent to each other, hitherto all will be well; but if they run again into one single cake, the process must be made again with another portion of the ore, in a more gentle fire.

"When the ore is grown cold, beat it to a powder somewhat finer, and roast it by the same method as before; then take it out, and if the powder is not melted yet, beat it again to a most subtil powder; in this you are to take care that nothing be lost.

"Roast the powder in a fire somewhat stronger, but for a few minutes only. If you do not then find the ore any way inclined to melt, add a little tallow, and burn it away under the muffle, and do the same another time again, till the fire being very

"bright, you no longer perceive any sulphureous, arsenical, unpleasant smell, or any smoak; and there remains nothing but a thin, soft powder, of a dark red, or blackish color.

*Remarks.* Every pyrites contains iron, with an unmetallic earth: to which sulphur, or arsenic, and most commonly both always join. Besides, there is copper in many pyrites; but sometimes more, and sometimes less: some of them are altogether destitute of copper; therefore, so much as pyrites differ with regard to the proportion of their constituent particles, so much do they differ as to their disposition in the fire. For instance, the more copper there is in pyrites, the more it inclines to colligation. The more sulphur and arsenic it has in it, the more quickly the melting of it will be procured, and the reverse: the more iron and unmetallic earth it contains, the more it proves refractory in the fire. Now if such pyrites melt in the roasting; as happens to some of them, if they grow but red-hot; the sulphur and arsenic that lies hidden therein are so strictly united with the fixed part, that you would in vain attempt to dissipate them. Nay, in this case, when it is reduced again into a powder, it requires a much greater time and accuracy in the regimen of the fire to perform the operation. For this reason, it is much better to repeat it with new pyrites. But you can roast no more than the double quantity at once of the ore you have a mind to employ in the foregoing experiment; to the end that, the precipitation by fusion not succeeding, there may remain still another portion entire; lest you should be obliged to repeat a tedious roasting. If you see the signs of a ferreous refractory pyrites, the operation must be performed with a greater fire, and much more quickly. However, take care not to do it with too violent a fire: for a great deal of copper is consumed not only by the arsenic, but also by the sulphur; and this happens even in vessels shut very close, when the sulphur is expelled by a fire not quite so strong; which a reiterated and milder sublimation of the sulphur

Lastly, the pyrites of a golden-yellow color which contains copper and sulphur, and the white pyrites which contains copper and arsenic, are considered

“ sulphur in a vessel both very clean and well closed, will clearly shew.

“ When the greatest part of the sulphur and the arsenic is dissipated, by such causes as promote colligation you may make a stronger fire: but then it is proper to add a little of some fat body; for this dissolves mineral sulphur; it changes the mixture of it in some part, which, for instance, consists in a certain proportion of acid and phlogiston, and at the same time hinders the metallic earth from being reduced into copper, by being burnt to an excess. From these effects the reason is plain, why assayers produce less metals in the trying of veins of copper, lead, and tin, than skilful smelters do in large operations. For the former perform the roasting under a muffle, with a clear fire, and without an oily reducing menstruum; whereas the latter perform it in the middle of charcoal or of wood, which perpetually emit a reductive phlogiston.

“ The darker and blacker the powder of the roasted ore appears, the more copper you may expect from it. But the redder it looks, the less copper and the more iron it affords; for roasted copper dissolved by sulphur or the acid of it is very black, and iron, on the contrary, very red.

## PROCESS V.

[Cramer Pr. xl.]

“ The precipitation of copper out of roasted ore of the last process.

“ DIVIDE the roasted ore into two parts: each of them shall go for a centner: add to it the same weight of sandiver, and four times as much of the black flux, and mix them well together. As for the rest, do all according to the process I. The precipitated regulus will be half malleable, sometimes quite brittle, now and then pretty much like pure copper in its color, but sometimes whitish, and even blackish. Whence it is most commonly called *black copper*, though it is not always of so dark a dye.

“ It is easy to conceive, that there is as great a difference between the several kinds of that metal called black copper, as there is between the pyritous and other copper-ores, accidentally mixed with other metallic and semi-metallic bodies. For all the metals, the ores of which are intermixed with the copper-ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Wherefore iron, lead, tin, the reguline part of antimony, bismuth, most commonly are mixed with black copper in a multitude of different proportions. Nay it is self-evident, that gold and silver, which are dissolvable by all these matters, are collected in such a regulus, when they have been first hidden in the ore. Besides, sulphur and arsenic are not always altogether absent. For they can hardly be expelled so perfectly by the many preceding roastings, but there remain some vestiges of them, which are not dissipated by a sudden melting, especially in a close vessel, wherein the flux swimming at top hinders the action of the air. Nay arsenic is rather fixed by the black flux, and assumes a reguline semi-metallic form, while it is at the same time preserved from dissipating by the copper.

## PROCESS VI.

[Cramer, Proc. xlii.]

“ To reduce black copper into pure copper by scorification.

“ SEPARATE a specimen of your black copper, of the weight of two small docimatical centners at least; and do it in the same manner, and with the same precautions, as if you would detect a quantity of silver in black copper.

“ Then with lute and coal-dust make a bed in the cavity of a test moistened: when this bed is dry, put it under the muffle of the docimatical furnace, in the open orifice of which there must be bright burning coals, wherewith the test must likewise be surrounded on all parts. When

as copper ores by several chemists and naturalists, See PYRITES. Henckel and Cramer remark, that no proper ore of copper is known which does not contain a considerable quantity of arsenic.

DXIV. O R E S of L E A D. Lead is seldom found native and malleable. Neither is it found in form of calx or precipitate, as copper is,

“ the whole is perfectly red-hot, put your  
“ copper into the fire, alone, if it contains  
“ lead; but if it is altogether destitute of  
“ it, add a small quantity of glass of lead,  
“ and with a pair of hand-bellows increase  
“ the fire, that the whole may melt with  
“ all speed: this done, let the fire be made  
“ a little less violent, and such as will suf-  
“ fice to keep the metallic mass well melted;  
“ and not much greater. The melted mass  
“ will boil, and scorias will be produced,  
“ that will gather at the circumference.  
“ All the heterogeneous matters being at  
“ last partly dissipated, and partly turned to  
“ scorias, the surface of the pure melted  
“ copper will appear. So soon as you see it,  
“ take the pot out of the fire, and extinguish  
“ it in water: then examine it in a balance,  
“ and if lead has been at first mixt with  
“ your black-copper, add to the regulus re-  
“ maining of the pure copper, one fifteenth  
“ part of its weight which the copper has  
“ lost by means of the lead, then break it  
“ with a vice; and thus you will be able  
“ to judge by its color and malleability, and  
“ by the surface of it after it is broken,  
“ whether the purifying of it has been well  
“ performed, or no. But whatever caution  
“ you may use in the performing of this pro-  
“ cess, the product will nevertheless be al-  
“ ways less in proportion than what you  
“ can get by a greater operation, provided  
“ the copper be well purified in the small  
“ trial.

“ *Remarks.* This is the last purifying  
“ of copper, whereby the separation of the  
“ heterogeneous bodies begun in the fore-  
“ going process is completed as perfectly  
“ as it possibly can be. For, except gold  
“ and silver, all the other metals and semi-  
“ metals are partly dissipated and partly  
“ burnt, together with the sulphur and  
“ arsenic. For in the fusion they either  
“ turn of themselves to scoria or fumes, or  
“ this is performed by means of iron, which  
“ chiefly absorbs semi-metals; sulphur and  
“ arsenic, and the destruction of it is at the  
“ same time accelerated by them. Thus

“ the copper is precipitated out of them pure;  
“ for it is self-evident, that the unmetallic  
“ earth is expelled, the copper being re-  
“ duced from a vitrescent terrestrial to a me-  
“ tallic state; and the arsenic being dissipated,  
“ by means of which the said earth has been  
“ joined to the coarser regulus's of the first  
“ fusion. But there is at the same time  
“ a good quantity of the copper that gets  
“ into the scorias: however, a great part  
“ of it may be reduced out of them by re-  
“ peating the fusion.

“ The fire in this process must be applied  
“ with all imaginable speed, to make it soon  
“ run: for if you neglect this, much of  
“ your copper is burnt: because copper that  
“ is only red-hot, cleaves much sooner, and  
“ in much greater quantity, into half scorified  
“ scales, than it is diminished in the same  
“ time when melted. However, too im-  
“ petuous a fire, and one much greater than  
“ is necessary for the fusion of it, destroys a  
“ much greater quantity of it, than a fire  
“ sufficient only to put it in fusion would  
“ do. For this reason, when the purifying  
“ is finished, the body melted must be ex-  
“ tinguished in water together with the  
“ vessel, lest being already grown hard, it  
“ should still remain hot for a while; which  
“ must be done very carefully to prevent dan-  
“ gerous explosions.

“ The scoria of the above process fre-  
“ quently contains copper. To extract  
“ which, let two or three decimassical cen-  
“ ters of the scoria, if it be charged with  
“ sulphur, be beat to a subtil powder, and  
“ mix it, either alone, or, if its refractory  
“ nature requires it, with some very fusible,  
“ common, pounded glass without a re-  
“ ducing saline flux, and melt it in a close  
“ vessel, and in a fire having a draught of  
“ air; by which you will obtain a regulus.  
“ But when the scoria has little or no sul-  
“ phur at all in it, take one centner of it,  
“ and with the black flux, manage it as  
“ you do the fusible copper ore; [Process I.]  
“ by which you will have a pure regulus.”



because it is much less liable to lose its phlogiston by the action of air and water: therefore almost all lead is found naturally mineralised.

### PROCESS VII.

[The following Process is translated from Mr. Gellert's *Elements of Assaying*, and describes a new method of assaying ores, concerning which, see a note (n) subjoined to the article of this Dictionary ESSAY OF ORES.]

#### *To assay Copper-ores.*

ROAST a quintal of ore [in the manner described in Process IV.]; add to it an equal quantity of borax, half a quintal of fusible glass, and a quarter of a quintal of pitch: put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water: cover the whole with pounded glass mixed with a little borax, or with decrepitated sea-salt: put a lid on the crucible, which you will place in an air-furnace, or in a blast-furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red color: then withdraw the crucible; and when it is cold, break it: observe if the scoria be well made: separate the regulus, which ought to be semiductile; and weigh it. This regulus is *black copper*, which must be purified, as in Pr. VI.

If the ore be very poor, and enveloped in much earthy and stony matters, to a quintal of it, a quintal and a half of borax; a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, must be added. The calx of lead will be revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glass will be sufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper-ore, as in pyrites, some pounds of

antimony, or of its regulus, may be added in the assay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

### PROCESS VIII.

#### *To assay Ores of Copper by humid Solution.*

SOME pyrites and ores contain so small a quantity of copper, that it cannot be separated by the above processes, but is destroyed by the repeated roastings and fusions. These, and indeed any copper-ores, may be assayed by humid solution, or by menstrua.

1. By roasting a sulphureous ore, the sulphur is burnt or decomposed, its phlogiston, with part of the acid evaporating, while the remaining part of the acid combines with the metals, especially with the copper and the iron contained in the ore. Accordingly, from an ore thus roasted, a vitriolic solution may be obtained by lixiviation with warm water, especially if the ore has been exposed, during a few days after it has been roasted, to a moist air; as the water thus gradually applied better unites with the combination of the metallic calxes with the concentrated vitriolic acid of the sulphur: but all the copper is not thus reduced by one operation to a vitriol. More sulphur must therefore be combined with the residuous ore by fusion, and must be again burnt off; that the remaining part of the copper may be attacked by some of the acid of the sulphur. By repeating this operation, almost all the copper and iron will be reduced to a vitriolic lixivium, from which the copper may be separated and precipitated by adding clean pieces of iron.

2. Copper-ores may be more easily assayed by humid solution, in the following manner: Roast the mineralised ores in the manner directed in Process IV. and pulverise them. If the ores be calciform, they do not require a previous roasting. Put this powder into a matras capable of containing ten times the quantity of the ore: pour upon the ore some water: set the matras in a sand-bath, that the

Lead is generally mineralised by sulphur. Its ores have a dark white, but a shining metallic color. These ores, although they form irregular masses, are internally regularly disposed, and seem to be composed of cubes of different sizes applied to each other, but not adherent. These ores are generally distinguished by the name *Galena*. They commonly contain about three quarters of lead and a quarter of sulphur. They are accordingly heavy and fusible, although much less so than pure lead.

Most lead-ores contain silver, none but those of Willach in Carinthia are known to be quite free from it: some of them contain so much of it, that they are considered as improper ores of silver. The smaller the cubes of galena are, the larger quantity of silver has been remarked to be generally contained. (n)

the water may boil: pour off the lixivium: add to the residuous ore more water with some vitriolic or marine acid: digest as before in the sand-bath, and add this lixivium to the former: repeat this operation, till you find that the acid liquor dissolves no more metal.

By adding clean plates of iron, you may precipitate the copper, which ought then to be collected, fused with a little borax and charcoal dust, and weighed.

We may remark, that although copper is not soluble by a dilute vitriolic acid, yet the calx of it obtained by roasting the ore, and also the calciform ores, are readily soluble in that acid.

3. Stahl advises to essay copper-ores by boiling them, after they have been roasted and powdered, in water, together with tartar and common salt, or with alum and common salt: but I have not found this method so effectual as the preceding (2).

(n) LEAD-ORES. Cronstedt doubts whether any native lead has been found. Linnæus says, he has seen what externally appeared to be such. The Author of the Dictionary is mistaken when he says, that no calx of lead is found. As lead unites strongly with vitriolic acid, we might expect to meet ochres of this metal as well as of copper. Accordingly, we find some *calciform ores* of lead. 1. A pure calx of lead, in form of a friable ochre, *cerussa nativa*, found on the surface of galena; or it is indurated with a radiated or fibrous texture, of a white or yellowish-green color, and resembling spar; it is called *spatum plumbi*, *sparry lead-ore*, and *lead-spar*. 2. A calx of lead is found mixed with calx of arsenic, forming the ore called *arsenicated lead-spar*. Sometimes also that calx is mixed with calcareous earth.

Lead is mineralised, 1. With *sulphur*; such are the several kinds of steel-grained and tellurated *galenas*, which also contain generally some silver. 2. With *sulphurated iron and silver*. It is fine-grained or tellurated, and is distinguishable from the former by yielding a black slag when scorified, whereas the former yields a yellow slag. 3. With *sulphurated antimony and silver*. *Plumbum stibiatum Linnæi*. Its color is similar to that of galena, and its texture is striated. 4. With *sulphur and arsenic*. This ore is soft, almost malleable, like lead. From this ore lead may be melted by the flame of a candle.

*Lead-ores may be essayed* by means of the black flux, in the manner directed by Mr. Cramer, and described in the Dictionary at the article *ESSAY of ORES*; or by the following process of Mr. Gellert.

Mix a quintal of roasted lead-ore with a quintal of calcined borax, half a quintal of glass finely pulverised, a quarter of a quintal of pitch, and as much of clean iron-filings: put this mixture into a crucible wetted with charcoal-dust and water: place the crucible before the nozzle of the bellows of a forge, and when it is red, raise the fire during fifteen or twenty minutes; then withdraw the crucible, and break it when cold.

Some very fusible ores, such as the galena of Derbyshire, may be essayed, as large quantities of it are smelted, without previous roasting, and without addition, merely by fusion during a certain time. For this purpose nothing more is requisite than to keep the ore melted in a crucible with a moderate heat, till all the sulphur is destroyed, and the metal be collected. To prevent the destruction of any part of the metal after it is separated from the sulphur, some charcoal dust

may

**DXV. TIN-ORES.** Tin is very seldom found pure, but almost always mineralised, and chiefly by arsenic.

The richest ore of arsenic is of an irregular form, of a black or tarnished color, and almost the heaviest of all ores. The cause of this extraordinary weight is, that it contains much more arsenic than sulphur, whereas most ores contain more sulphur than arsenic.

The most common tin-ore is of the color of rust, which proceeds from a quantity of iron, or of iron-ore mixed with it. The tin-ores of Saxony and Bohemia appear to be all of this kind.

One kind of tin-ore is semi-transparent and like spar. Lastly, several kinds of garnets are enumerated by mineralogists amongst tin-ores, because they actually contain tin.

The county of Cornwall, in England, is very rich in tin-ores, and the tin contained in them is very pure. From tin-mines in the East-Indies tin is brought, called *Malacca tin*. No mines of tin have been discovered in France; only in Bretagne garnets are found which contain some tin. (o)

**DXVI. ORES of IRON.** No iron is found in its metallic state, although several sands and earths have the appearance of iron, and are even attractable by a magnet.

may be thrown over the ore, when put into the crucible: but if the galena be mixed with pyrites, especially arsenical pyrites, it requires much roasting and saline fluxes.

(o) **TIN-ORES.** *Native tin* is said to have been found in Saxony and Malacca. Its ores are all of the calciform kind, excepting *black-lead*, which appears to be tin mineralised by sulphur and iron. See **MOLYBDENA**.

The calciform ores of tin are, 1. *Tin-stone*, which is of a blackish-brown color, and of no determinate figure; and *tin-grains*, or *crystals of tin*, which resemble garnets, and are of a spherical or polygonal figure, which they have probably acquired by the attrition of their angles. The tin-stone seems to consist of attrited tin-grains. This ore is calx of tin united with calx of arsenic, and frequently with calx of iron. 2. *Garnets* are said to contain calx of tin united with calx of iron. 3. *Manganese* is said also to contain tin. See **MANGANESE**.

*Ores of tin may be essayed* in the same manner, according to Cramer, as he directed for the essay of lead-ores. See **ESSAY of ORES**. He further makes upon this essay the following remarks.

1. *Tin-ore*, on account of its greater gravity, admits better of being separated, by elutriation or washing, from earths, stones and lighter ores. 2. A most exact separation of earths and stones ought to be made, because

the scorification of these by fluxes requires such a heat as would destroy the reduced tin.

3. The iron ought to be separated by a magnet. 4. By a previous roasting, the arsenic is dissipated, which would otherwise carry off a great deal of tin along with it in a melting heat, would change another part of it into ashes, and would vitiate the remaining tin. 5. The essay of tin is very precarious and uncertain; because tin once reduced is easily destructible by the fire, and by the saline fluxes requisite for the reduction.

Mr. Gellert directs, that ores of tin should be essayed in the following manner:

Mix a quintal of tin-ore, washed, pulverised, and twice roasted, with half a quintal of calcined borax, and half a quintal of pulverised pitch: these are to be put into a crucible moistened with charcoal-dust and water, and the crucible placed in an air-furnace: after the pitch is burnt, give a violent fire during a quarter of an hour; and then withdraw your crucible. If the ore be not very well washed from the earthy matters, as it ought to be, a larger quantity of borax is requisite, with some powdered glass, by which the too quick fusion of the borax is retarded, and the precipitation of the earthy matters is prevented. If the ore contains iron, to the above mixture may be added some alkaline salt.

Neither

Neither is iron generally mineralised so distinctly as other metals are, unless in pyrites and ores of other metals.

Most of the minerals called iron-ores have an earthy, rusty, yellowish or brownish appearance, which proceeds from the facility with which the true iron-ores are decomposed.

Iron is the most common and most abundant of all metals. In Europe, at least, we cannot find an earth, a sand, a chalk, a clay, a vitrifiable or calcinable stone, or even the ashes of any substance, which do not contain an earth convertible into iron. All earths and stones which are naturally yellow or red, and all those which acquire these colors by calcination, receive them from the ferruginous earth mixed with them. The yellow and red ochres consist almost solely of this earth: the black and heavy sands are generally very ferruginous.

One of the richest iron-ores is a heavy stone, the surface of which, when newly broken, is red and bluish, and is exceedingly hard. A quintal of this ore furnishes from sixty to eighty pounds of the best iron by a single fusion, according to Mr. Cramer.

The iron-ore most commonly found is a stone of the color of rust, of an intermediate weight betwixt those of ores in general and of unmetallic stones. This ore has no determinate form, and easily furnishes an iron of good quality.

Blood-stone or hematites, sanguine or red-chalk, and emery, are iron-ores; some of which, for instance, blood-stone, are almost all iron. Most of these substances require but a slight calcination to be rendered very attractable by a magnet, and soluble in aqua fortis: but the iron obtained from them is of a bad quality, and they are therefore neglected. Iron from the hematites is very brittle; that obtained from ochres is red-short. All these iron-ores are so refractory, that they can scarcely be fused.

Iron-ores are very various in their form; or rather they have no determinate form. Sometimes they are earths, sometimes stones, sometimes grains. Accordingly, those naturalists who attend only to the external form of things in classing and subdividing minerals, have been obliged to multiply the names of iron-ores: hence they are called *iron-ores in form of pease, of beans, of coriander seeds, of pepper-corns, of cinnamon, &c.* which Mr. Cramer treats as ridiculous trifles. (p)

(p) ORES of IRON. I. Malleable native iron is mentioned by Wallerius, Linnæus, and Cartheuser. II. The calciform ores of iron are pure, or mixed. The pure calciform ores are, 1. Friable, as the martial ochre, which is either in powder, or concreted, as the bog-ore; or, 2. they are indurated, Hematites. See HEMATITES. The mixed calciform ores consist of the calx of iron mixed with heterogeneous substances: 1. With calcareous earth, forming the white spathose iron ore. 2. With siliceous earth, forming martial jasper. 3. With garnet-earth, forming garnets and basaltæ. 4. With argillaceous earths, forming boles. 5. With micaceous earth, forming colored micas. 6.

With manganese. See MANGANESE. 7. With an unknown earth, which hardens like cement in water; Terras. This is chiefly found in the neighbourhood of volcanos. III. Iron is mineralised, 1. With sulphur, forming martial pyrites; black iron-ore, which is magnetic, the quantity of sulphur being very small; the lead-stone. With arsenic; white pyrites. 3. With sulphur and arsenic; the arsenical pyrites. 4. With vitriolic acid; native martial vitriol. 5. With phlogiston; martial coal-ore. 6. With other sulphurated and arsenicated metals.

Ores of iron may be essayed by the following Processes.

**DXVII. ORES of MERCURY.** Mercury is sometimes found pure, fluid, and in its proper metallic state, only mixed with earths and stones. Such are the ores of mercury found near Montpellier, in Tully, and in other places.

### PROCESS I.

[CRAMER'S *Art of Essaying*, *Process* 54.]

*To reduce a precipitate Iron out of its Ore in a close Vessel.*

“ROAST for a few minutes in a test under a muffle, and with a pretty strong fire, two centners of the small weight of your iron ore grossly pulverised; that the volatiles may be dissipated in part, and the ore itself be softened in case it should be too hard. When it is grown cold, beat it extremely fine, and roast it a second time, as you do the copper-ore, but in a much stronger fire, till it no longer emits any smell; then let it grow cold again. Compose a flux of three parts of the white flux, with one part of fusible pulverised glass, or of the like sterile unsulphureous scorias, and add sandiver and coal-dust, of each one half-part; add of this flux three times the quantity of your roasted ore, and mix the whole very well together; then chuse a very good crucible, well rubbed with lute within, to stop the pores which may be here and there unseen; put into it the ore mixed with the flux; cover it over with common salt; and shut it close with a tile and with lute applied to the points.

“Put the wind-furnace upon its bottom part, having a bed made of coal-dust. [See *Plate III.*] Introduce besides into the furnace a small grate supported on its iron bars, and a stone upon it; whereon the crucible may stand as on a support: surround the whole with hard coals, not very large, and light them at top; when the vessel begins to grow red, which is indicated by the common salt's ceasing to crackle, stop with gross lute the holes of the bottom part, except that in which the nozzle of the bellows is received: blow the fire, and excite it with great force, adding now and then fresh fuel, that the vessel may never be naked at top: having

“thus continued your fire in its full strength for three quarters of an hour, or for a whole hour, take next the vessel out of it, and strike several times the pavement upon which it is set, that the small grains of iron which happen to be dispersed may be collected into a regulus, which you will find after having broken the vessel.

“When the regulus is weighed, try its malleability; then make it red-hot; and when so, strike it with a hammer: if it bears the strokes of a hammer, both when red-hot and when cold, and extends a little, you may pronounce your iron very good: but if, when either hot or cold, it proves brittle, you may judge it to be not quite pure, but still in a semi-mineral condition.

“Remarks. The arsenic, but especially the sulphur, must be dissipated by roasting; for the former renders the iron brittle, and the latter not only does the same, but, being managed in a close vessel, with a saline alkaline flux, turns to liver of sulphur; to the action of which iron yielding in every respect, it can upon no account be precipitated; and if not the whole, a great part of it, at least, is retained by the sulphureous scoria; so that in this case you commonly in vain look for a regulus.

“The iron obtained from this first precipitation has hardly ever the requisite ductility, but is rather brittle: the reason of which is, that the sulphur and arsenic remain in it; for notwithstanding that the greatest part of these is dissipated by roasting, yet some part adheres so strictly, that it can never be separated but with absorbent, terrestrial, alkaline ingredients, that change the nature of the sulphur. For which reason, in larger operations, they add quicklime, or marble-stones that turn into quicklime; which, while they absorb the said minerals, are, by it, and by help of the destroyed part of the iron, brought to a fusion, and turn to a vitrified scoria; although, at other times, they resist so much by their own nature a vitrification. “Another cause of the brittleness of iron is the

But the largest quantity of the mercury found in the earth is mineralised by sulphur, and consequently is in the form of cinnabar. See CINNABAR.

"the unmetallic earth, when it is not yet separated from it; for the iron-ore contains a great quantity of it, and in the melting remains joined with the reguline part: whence the iron is rendered very coarse and brittle. Some iron-ores are altogether untractable: nevertheless, the reguluses produced out of them, when broken, have sometimes a neat semimetallic look; which proceeds undoubtedly from a mixture of a small quantity of some other metal or semimetals.

## PROCESS II.

[The following Process for assaying iron-ores, and ferruginous stones and earths, is extracted from Mr. Gellert's *Elements of Assaying*.]

ROAST two quintals of iron-ore, or of ferruginous earth: divide the roasted matter into two equal parts; to each of which add half a quintal of pulverised glass, if the substance be fusible, and contains much metal; but if otherwise, add also half a quintal of calcined borax. If the roasting has entirely disengaged the sulphur and arsenic, an eighth part, or even half a quintal, of quicklime may be added. With the above matters, mix twelve pounds of charcoal powder.

Take a good crucible, and cover the bottom and sides of its inner surface with a paste made of three parts of charcoal-dust and one part of clay beat together. In the hollow left in this paste put the above mixture; press it lightly down; cover it with pulverised glass; and put on the lid of the crucible.

Place two such crucibles at the distance of about four fingers from the air-pipe, in such a manner that the air shall pass betwixt them at about the third part of the height from the bottom: fill the space betwixt the two crucibles with coals of a moderate size: throw lighted coals upon them, that the fire may descend and make them red-hot from top to bottom: at first let the bellows blow softly, and afterwards strongly during an hour, or an hour and a quarter: then take away the crucible, and break it when cold. A regulus

will be found in the bottom, and sometimes some small grains of iron in the scoria, which must be separated and weighed along with the regulus: then try the regulus, whether it can be extended under the hammer, when hot and when cold.

*Remarks.* To disengage a metal from the earthy matters mixed with it by fire, we must change these matters into scoria or glass. This change may be effected by adding some substance capable of dissolving these matters; that is, of converting them into a scoria or glass, from which the metallic matters may, by their weight, separate and form a regulus at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful solvent of earths and stones: but the alkali does also dissolve iron, especially when this is in a calcined or earthy state; and this solution is so much more complete, as the fire is longer applied. Hence, in ordinary assays, where an alkaline salt is used, little or no regulus of iron is obtained. Now, glass acts upon, and dissolves earths and stones; but not, or very little, iron: consequently glass is the best flux for such assays: and experience confirms this assertion. If the ore contains but little iron, we may also add to the glass some borax; but borax cannot be employed singly, because it very soon fuses, and separates from the ore before the metal is revived. Quicklime is added, not only to absorb the sulphur and arsenic remaining in the ore, but also because it dissolves and vitrifies the stony and earthy matters of iron-ores, which are generally argillaceous. For which reason, in the large operations for smelting iron-ore, quicklime and even in certain cases gypsum are commonly added, to facilitate the fusion.

The reduction of iron-ore, and even the fusion of iron, requires a violent and long-continued heat: therefore, in this operation, we must not employ an inflammable substance, as pitch, that is soon consumed, but charcoal pulverised, which in close vessels is not sensibly wasted. Too much charcoal must not be added, else it will prevent the action of the glass upon the earthy matter of the ore, and consequently the separation of the metallic part. Experiments have taught me, that

Mercury is never mineralised by arsenic. The richest mine of mercury is that of Almaden, in Spain. (7)

that one part of charcoal-dust to eight parts of ore was the best proportion.

When iron is surrounded by charcoal, it is not decomposed or destroyed: hence the iron of the ore, which sinks into the hollow made of paste of charcoal-dust and clay, remains there unhurt. The clay is added in this paste to render it more compact, and to keep the fluid iron collected together.

The air is directed betwixt the crucibles; because if it was thrown directly upon them, they would scarcely be able to resist the heat. The space betwixt the air-pipe and the crucibles ought to be constantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is seldom obtained in this first operation. The sulphur and arsenic, and frequently also an earthy matter adhering to the iron, prevent these qualities.

(7) ORES OF MERCURY. Besides the ores of mercury enumerated by the author of the Dictionary, Linnæus and Cronstedt mention a singular ore, in which the mercury is mineralised by sulphur and by copper. It is said to be of a blackish-grey color, of a glassy texture, and brittle. When the mercury and sulphur are expelled by fire, the copper is discovered by giving an opaque red color to glass of borax, which, by continuance and encrease of heat, becomes green and transparent. See CINNABAR.

Cramer directs, that ores of mercury should be essayed by the following Processes:

### PROCESS I.

[Cramer's Art of Assaying, Proc. 58.]

"To separate Mercury out of an unsulphureous Ore by Distillation.

"TAKE a lump of the pulverised ore, one common pound, which must stand for one centner: put it into a glass retort perfectly clean, well loricated, or coated up to half the length of its neck: this must be very long, and turned backwards with such a declivity, that a glass recipient may be perpendicularly applied to it: but you must chuse a retort small enough, that the belly of it may be filled hardly two-

"thirds with the ore: this retort must be placed so, that nothing of the fluid adherent to the neck of it may fall into the cavity of the belly, but that the whole may run forward into the recipient. Finally, have a small recipient full of cold water: let it be perpendicularly situated, and receive the neck of the retort in such manner that the extremity of it be hardly one half-inch immersed into the water.

"Let the retort be surrounded with hot burning coals placed at some distance in form of a circle, lest the vessel should burst by too sudden a heat: then by degrees bring the burning coals nearer and nearer, and at last surround the whole retort with them and with fresh charcoal, that it may grow slightly red-hot: this fire having been continued for an hour, let the retort cool of itself: then strike the neck of it gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and the water separated from the mercury by filtration, and let the mercury be weighed. This operation may be more conveniently performed in a sand-bath, in which case the pot containing the sand must be middling red-hot, and the retort be able to touch the bottom of it immediately; nor is it then necessary that the retort be loricated."

### PROCESS II.

[Cramer's Art of Assaying, Proc. 59.]

"To revive Mercury from a sulphureous Cinnabar-ore.

"BEAT your ore extremely fine, and mix it exactly with an equal portion of iron filings, not rusty; and proceed to distill it with the same apparatus as in the former Process; but urge it with the strongest fire that can be made,

"Cinnabar may be separated from stones by sublimation thus: Beat it to a fine powder, and put it into a small, narrow glass or earthen cucurbit, the belly of which it must not fill more than one-third part: stop the orifice at top; this must

**DXVIII. ORE of the REGULUS of ANTIMONY, or ANTIMONY.** Native regulus of antimony was first observed by Mr. Swab, in Sweden, in the mine of Salberg, and described by him in the Memoirs of the Swedish Academy in 1749. Mr. Wallerius mentions it in his Mineralogy.

Regulus of antimony is generally united with sulphur, with which it forms antimony, which ought to be considered as a true ore of the regulus of antimony.

Another ore of regulus of antimony is also known, of a red color, in which the regulus is mineralised both by arsenic and by sulphur. This ore resembles some iron ores, and some kinds of blend. It is distinguished by its great fusibility, which is such, that it may be easily melted by the flame of a candle. (r)

“ must be very narrow, to hinder the free  
“ action of the air. Put this small cucurbit  
“ in an earthen pot above two inches wide  
“ in diameter, and gather sand around this  
“ pot about as high as the pulverised ore  
“ rises in the cucurbit. Then put it upon  
“ burning coals in such manner that the bot-  
“ tom of the pot may be middling red-hot.  
“ Thus will your cinnabar ascend and form  
“ a solid ponderous ring, which must be got  
“ out by breaking the vessel.”

(r) **ORES of REGULUS of ANTIMONY.**

1. The native regulus of antimony, observed by Mr. Von Swab, is said by that author to have differed from the regulus of antimony obtained from ores, in these two properties, that it was capable of being easily amalgamated with mercury, and that its calx shot into crystals during the cooling.

Besides the ores of regulus of antimony enumerated in the Dictionary, this semimetal is also found in ores of other metallic substances, as in the *plumose silver-ore*, and in the *stibiated lead-ore*. See **ORES of SILVER and of LEAD**.

The ores of antimony may be assayed by the following processes described by Mr. Cramer.

### PROCESS I.

[Cramer's Art of Assaying, Process lx.]

“ To obtain antimony from its ore.

“ **CHUSE** a melting crucible or an  
“ earthen pot not glaz'd that may contain  
“ some common pounds of the ore of an-  
“ timony, broken into small bits. Bore at  
“ the bottom of the crucible some small holes,

“ two lines in diameter. Let the bottom of  
“ the vessel be received by the orifice of a  
“ smaller one, upon which it must be put ;  
“ and when the ore is put into it, let it be  
“ covered with a tile, and all the joints be  
“ stop'd with lute.

“ Put these vessels upon the pavement of  
“ a hearth, and put stones all round them at  
“ the distance of six inches. Fill this inter-  
“ mediate space with ashes, so high that  
“ the inferior pot be covered to the upper  
“ brim. Then put fresh and burning coals  
“ upon it, and with a pair of hand-bellows  
“ excite the fire, till the upper vessel grows  
“ red-hot : take off the fire a quarter of an  
“ hour after, and when the vessels are grown  
“ cold, open them. You will find that the  
“ melted antimony has run through the holes  
“ made at the bottom of the upper vessel  
“ into the inferior one, where it is col-  
“ lected.

### PROCESS II.

[Cramer's Art of Assaying, Proc. lxi.]

“ To roast crude antimony, or its ore, with or  
“ without addition.

“ **CHUSE** an earthen, flat, low dish, not  
“ glaz'd, and if it cannot bear being made  
“ middling red-hot, cover it over with a  
“ coat of lute without. Spread it thinly over  
“ with crude antimony, or with its ore,  
“ beaten to a pretty coarse powder, not ex-  
“ ceeding a few ounces at once. Put the  
“ dish upon a fire-pan, having a few burn-  
“ ing coals in it : increase the fire till it be-  
“ gins to smoke a little. Meanwhile you  
“ must



**DXIX. ORES of BISMUTH.** Bismuth is chiefly mineralised by arsenic, and generally it is united with other ores, particularly with that of cobalt. (s)

" must incessantly move the powder with a piece of new tobacco-pipe ; for this causes the sulphur to evaporate the sooner. If you encrease the fire a little too soon, the powder immediately gathers into large clois, or even begins to melt. When this happens, take it immediately off the fire before it melts entirely. Then pulverise it again, and finally make a gentle fire under it. Your black thinning powder will assume an ash-color almost like that of earth, and become more refractory in the fire ; wherefore you may then encrease the fire till your powder grows middling red-hot, and let it last till it ceases to smoke. If you add to your crude antimony pulverised, half or an equal quantity of charcoal dust, and perform the rest as above, the roasting will be done more conveniently : for it does not gather so easily into clots, and melts with much greater difficulty. When part of the sulphur is evaporated, add some fat to it at several times. Thus you will sooner finish the operation, and the remaining calx will not be burnt to excess. However, if it be thus exposed to too violent and long-lasting a fire, a great quantity of it evaporates ; nor does it cease entirely to smok in a great fire. And it will be enough, if growing middling red-hot, it does no longer emit the unpleasant smell of the acid of sulphur."

### PROCESS III.

[Cramer, Proc. lxii.]

"To reduce a calx of antimony into a semimetallic  
" *regulus*."

" MIX some calx of antimony with a quarter part of the black flux, and put it into the crucible. Cover the vessel with a tile ; make the fire as quickly as the vessel can bear it, but not greater than is necessary to melt the flux. When the whole has been well in fusion for half a quarter of an hour (which may be tried with a tobacco-pipe, taking off the tile) pour it into the melting cone, which must be warm and done over with tallow. Then immediately strike

" the cone several times. You will find, when the cone is inverted, a regulus, above which is a saline scoria."

The methods of *calcining antimony by means of nitre* ; of obtaining a *regulus of antimony* without a previous calcination or roasting, by throwing a mixture of powdered antimony, tartar, and nitre into a red-hot crucible, and by fusing this mixture ; and of obtaining a *martial regulus of antimony* ; are described at the articles of the Dictionary, **ANTIMONY**, and **REGULUS of ANTIMONY**.

(s) **ORES of BISMUTH.** I. Bismuth is found *native*, resembling the regulus of bismuth. II. An *ore* of bismuth, of a whitish yellow color, is mentioned by Cronstedt, and is different from the ore improperly called *flowers of bismuth*, which is a calx of cobalt. III. Bismuth is mineralised ; 1. By *sulphur*. This ore has the appearance of galena. 2. With *sulphurated iron*. Bismuth is found also in cobalts (*see COBALT*), and in some ores of silver.

*Ores of Bismuth* may be *assayed* by the following process.

### PROCESS I.

[Cramer, Proc. lxiv.]

"To melt bismuth from its ore."

" **BISMUTH** ore may be melted with the same apparatus as was directed for the fusion of crude antimony out of its ore. [See **ORES of ANTIMONY**.] Or you may beat your ore to a very fine powder, with the black flux, sandiver, and common salt, in a close vessel, like the ore of lead, or of tin, and melt it in a middling fire, having a draught of air. But as this semimetal is destructible and volatile, you must as quick as possible apply to it that degree of fire which the flux requires to be melted ; and so soon as it is well melted, the vessel must be taken out of the fire ; and when it is grown quite cold and broken, you will find your regulus."

Mr. Gellert directs that ores of bismuth should be assayed by fusing a quintal of pulverised ore with half a quintal of calcined

**DXX. ORES of the REGULUS of COBALT,** or **COBALT.** Cobalt is a grey-colored mineral, with more or less of a metallic appearance. Its grain is close; it is compact and heavy, and frequently covered with an efflorescence of peach-colored flowers. Of this several kinds are known. All the true cobalts contain the semimetal called *regulus of cobalt*, the calx of which becomes blue by vitrification. This regulus is mineralised in cobalt by sulphur, and especially by a large quantity of arsenic. Some cobalts also contain bismuth and silver.

Authors have given the name of cobalt to many minerals, although they do not contain the semimetal above-mentioned, but only because they externally resemble the ore of the regulus of cobalt. But these minerals can only be considered as false cobalts. They are distinguishable from true cobalt by trying whether they can yield the blue glass called *smalt*, and the *sympathetic ink*. The red efflorescence is also a mark by which true cobalt is distinguishable from the false: but this efflorescence only happens when the ore has been exposed to a moist air.

The principal mines of cobalt are in Saxony, where they are dug for the sake of obtaining *zaffre*, *azure-blue*, or *smalt*, and *arsenic*. Very fine cobalt is also found in the Pyrenean mountains.

Cobalt is heavier than most other ores, from the large quantity of arsenic it contains; and in this respect it resembles the ore of tin. (t)

**DXXI. ORES of ZINC.** The proper ore of zinc is a substance which has rather an earthy or stoney than metallic appearance, and is called *calamy*, *calamine*, or *lapis calaminaris*. This stone, although metallic, is but moderately heavy, and has not the brilliancy of most other ores. Its color is yellow, and like that of rust. It is also less dense than other metallic minerals. It seems to be an ore naturally decomposed. The calamine is not worked directly to obtain zinc from it, because this would only succeed in close vessels, and consequently with small quantities, according to Mr. Margraaf's process. But it is successfully employed for the conversion of copper into brass by cementation, by which the existence of zinc in that stone is sufficiently proved.

Mr. Wallerius enumerates also amongst the ores of zinc a very compounded mineral, consisting of zinc, sulphur, iron, and arsenic. This mineral called *blend* resembles externally the ore of lead, and hence has been called *false galena*. These blends have different forms and colors, but are chiefly red, like the red ore of antimony.

Zinc is obtained from certain minerals in the East Indies, of which we know little. (u)

borax, and half a quintal of pulverised glass, in order to vitrify the adherent earths and stones which envelop the bismuth. But probably the heat requisite for this vitrification would volatilise part of the bismuth.

If the ore be of the kinds above described, mineralised by sulphur, or by sulphur and iron, a previous roasting would be expedient, which may be performed in the same man-

ner as is directed for the roasting of antimony.

(t) The ores of cobalt are enumerated in a note under the article **COBALT**. The *essay* of cobalt is described at the article **REGULUS of COBALT**.

(u) **ORES of ZINC.** I. *Caliform ores* of zinc, according to Cronstedt, are pure or mixed. The pure are indurated, and sometimes crystallised, resembling lead-spar. The mixed

**DXXII. ORES of ARSENIC.** The minerals which contain the largest quantity of arsenic are cobalts and white pyrites, although it is also contained in other ores, it being one of the mineralising substances. But as cobalt must be roasted to obtain the sulphur it contains, the arsenic also which rises during this torrefaction is collected, as we shall see in the article *SMELTING of ORES, and the particular articles of each of the metallic substances mentioned in this article.* (x).

mixed ore contains also some calx of iron. This is *calamine*. It is whitish, yellowish, reddish, or brown. II. Zinc is *mineralised*, 1. By *sulphurated iron*. Ore of zinc. Walle-rius lays, lead is sometimes contained in this ore. It is white, blue, or brown. 2. By *sulphur, arsenic, and iron*. Blend, or *pseudo-galena* or *falso-galena*, or *black-jack*. See **FALSE-GALENA**. These are of various colors, white, yellowish, brown, reddish, greenish, black. They consist of scales, or are tessellated. Mr. Cronstedt thinks, that in blends the zinc is mineralised in the state of a calx, and in the ore of zinc, in its metallic state.

Although the minerals above enumerated have been known, from their property of converting copper into brass, to be ores of zinc, yet the method of assaying them so as to obtain the contained zinc was not known, or at least not published, before Mr. Margraaf's Memoir of the Berlin Academy for the year 1746, upon that subject. That very able chemist has shewn that zinc may be obtained from its ores, from the flowers, or from any other calx of zinc, by treating these with charcoal dust, in close vessels, to prevent the combustion of the zinc, which happens immediately upon its reduction, when exposed to air. For this purpose, he put a quantity of finely powdered calamine, or roasted blend, or other calx of zinc, well mixed with an eighth part of charcoal-dust, into a strong, luted earthen retort, to which he fitted a receiver. Having placed his retort in a furnace and raised the fire, he applied a violent heat during two hours. When the vessels were cold, and broken, he found the zinc in its metallic form adhering to the neck of the retort.

The chief difficulty in this operation is to get an earthen retort sufficiently compact to retain the vapor of the zinc, (for it easily pervades the Hessian crucibles, Stourbridge melting-pots, and similar vessels, as may be seen from the quantity of flowers which ap-

pear upon their outer surface, when zinc or its calxes and any inflammable matter have been exposed to heat within these vessels) and at the same time sufficiently strong to resist the violent fire which Mr. Margraaf requires.

A pretty exact assay of an ore of zinc may be made in the following manner.

Mix a quantity of pulverized roasted ore or calx of zinc with an eighth part of charcoal-dust. Put this mixture into a crucible capable of containing thrice the quantity. Diffuse equally amongst this mixture a quantity of small grains or thin plates of copper equal to that of the calamine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper; and lastly, cover this latter portion of copper with charcoal-dust. Lute a lid upon the crucible; and apply a red heat during an hour or two. The copper or part of it will unite with the vapor of the zinc, and be thereby converted into brass. By comparing the weight of all the metal after the operation with the weight of the copper employed; the weight acquired, and consequently the quantity of zinc united with the copper, will be known. The copper which has not been converted into brass, or more copper with fresh charcoal-dust, may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, that any zinc remaining in the ore may be thus extracted. A curious circumstance is, that a much greater heat is required to obtain zinc from its ore, by distillation, than in the operation, now described, of making brass; in which the separation of the zinc from its ore seems to be facilitated by its disposition to unite with copper.

(x) **ORES of ARSENIC.** I. *Regulus of arsenic* is found *native*. It is of a leaden color; it burns with a small flame; and is dissipated, leaving generally a very small quantity of calx of bismuth, or of calx of cobalt, and a very little silver. When it is of a solid and testaceous

## DXXIII. OSTEOCOLLA. (y)

testaceous texture, it has been improperly called *testaceus cobalt*, in German, *schwebelk*. II. Calx of arsenic is found in form of powder: *native flowers of arsenic*; or of radiated semitransparent crystals; *native crystals of arsenic*. III. Calx of arsenic is mixed, 1. With sulphur: when yellow, it is called *orpiment*; when red, it is called *native realgar*: the difference of color depends on the proportion of the two component parts. 2. With calx of tin; *tin-grains*. 3. With sulphur and silver, in the *red silver-ore*. 4. With calx of lead, in the *lead-spar*. 5. With calx of cobalt, in the *effluence of cobalt*. IV. Arsenic is mineralized; 1. With sulphurated iron; *arsenical pyrites*. 2. With iron only; *white pyrites*, or *mispickel*. 3. With cobalt, in all almost cobalt-ores. 4. With silver. See ORES of SILVER. 5. With copper. See ORES of COPPER. 6. With antimony. See ORES of ANTIMONY. *Cronstedt*.

Arsenic may be separated from its ore or earthy matters, with which it happens to be mixed, by *sublimation*, according to the following process of Mr. Cramer. [Art of Assaying, Proc. lxix.]

"DO every thing as was said about mercury, or sulphur; but let the vessel which is put into the fire with the ore in it be of earth or stone, and the recipient be of glass, and of a middling capacity. Nor is it necessary that this should be filled with water, so it be but well luted. The fire must likewise be stronger, and continued longer than for the extracting of sulphur. Nevertheless every kind of arsenic cannot be extracted in a confined fire: for it adheres to the matrix more strongly than sulphur and mercury. You will find in the part of the vessel which is more remote from the fire, pulverulent and subtle flowers of arsenic; but there will adhere to the posterior part of the neck of the retort small solid masses, shining like small crystals, transparent, sometimes gathered into a solid sublimate, and perfectly white, if the ore of the arsenic was perfectly pure; which, nevertheless, happens very seldom. The flowers are most

"commonly thin, and of a grey color: which proceeds from the phlogiston mixed with the mass. They are often of a citron or of a golden color, which is a sign that there is in the mixture some mineral sulphur; and if the sublimate be red or yellow, it is a sign of much sulphur.

"As all the arsenic contained in the ore is not expelled in close vessels, you must weigh the residuum; then roast it in a crucible till it smoaks no longer, or rather in an earthen flat vessel not glazed, and in a strong fire to be stirred now and then with a poker, and then weigh it when grown cold: you will be able thus to know how much arsenic remained in the close vessel; unless the ore contain bismuth."

If the arsenic be sulphurated, it may be purified by triturating it with mercury or with fixed alkali, and by subliming the arsenic from the remaining sulphurated mercury or alkali. See ARSENIC. The method of obtaining a regulus of arsenic is described at the article REGULUS of ARSENIC.

(y) OSTEOCOLLA is a substance formed by stoney matters filling up the interstices of rotten roots of trees. It has been particularly described by Mr. Gleditsch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the Year 1748. The former author relates, that it is dug from grounds containing fine sand and a fine calcareous earth; and that sometimes the roots of living trees had been found converted into this stoney substance. From Mr. Margraaf's experiments we find, that the osteocolia examined by him was composed of a fine sand, a fine calcareous earth, and some rotten remains of a root. Neuman also says, that he found marine acid in osteocolia. But nothing of that or any other acid could be discovered by Margraaf. Neuman also says, that he totally dissolved osteocolia by means of dilute vitriolic acid. Hence the substances examined by these two chemists seem to have been different. Differences must arise from the different qualities of the soil in which osteocolia is found.

## P.

DXXIV. **P**ANACEA (MERCURIAL). This name, which signifies *universal remedy*, is given to a preparation of mercury much employed in the cure of those diseases, against which that metallic substance is effectual. To make the panacea, sweet mercury is to be taken and sublimed nine times, then reduced to a fine powder, and digested in good spirit of wine, which is, lastly, to be distilled off, or only decanted.

Sweet mercury is corrosive sublimate entirely saturated with mercury, and thrice sublimed. Corrosive sublimate is rendered milder by the operations which change it into sweet mercury, and retains nothing of its causticity but a purgative quality; but by the nine sublimations which change sweet mercury into the panacea, the saline qualities of this mercurial preparation are so diminished, that after all these sublimations it has not even a purgative virtue.

These changes are probably produced, because at each sublimation a small quantity of marine acid is separated; so that the panacea contains but very little of this acid, and is little else than very pure mercury, united with that quantity only of marine acid, which is necessary to deprive it of its fluid metallic form, and to give it a saline appearance.

The panacea therefore taken internally produces only the effects of mercury much divided, and in such a state that its molecules may be divided more and more by the action of the vessels and liquors of the body, without being capable of uniting again so as to form fluid mercury. This remedy is therefore very proper for exciting salivations, and produces nearly the same effects as mercury administered by friction and fumigation.

We may employ the panacea with success in venereal diseases, and in others in which preparations of mercury are suitable. It may be given conveniently in pills or in a bolus, mixed with proper substances, and cannot be given in any other manner, because it is insoluble, and is very heavy. The dose of it is from six to twenty-four grains, and even more in some circumstances. See the article MERCURY, for the medicinal uses of this preparation.

**DXXV. PARTING.** Parting is an operation by which gold and silver are separated from each other. As these two metals resist equally well the action of fire and of lead, they must therefore be separated by other methods. This separation could not be effected, if they were not soluble by different menstruums.

Nitrous acid, marine acid, and sulphur, which cannot dissolve gold, attack silver very easily; and therefore these three agents furnish methods of separating silver from gold, or of the operation called *parting*.

Parting by nitrous acid is the most convenient, and therefore most used, and even almost the only one employed by goldsmiths and coiners. Wherefore it is called simply *parting*. That made with the marine acid is only made by cementation, and is known by the name of *concentrated parting*. Lastly, parting by sulphur is made by fusion, which the chemists call the *dry way*, and is therefore called *dry parting*. We shall describe each of these methods.

**DXXVI. PARTING by AQUA FORTIS.** Although parting by aqua fortis be easy, as we have said, it cannot however succeed, or be very exact, unless we attend to some essential circumstances.

1. The gold and silver must be in a proper proportion; for if the gold was in too great quantity, the silver would be covered and guarded by it from the action of the acid.

Therefore when essayers do not know the proportion of these two metals in the mass to be operated upon, they discover it by the following method:

They have a certain number of needles composed of gold and silver alloyed together in graduated proportions, and the alloy of each needle is known by a mark upon it. These are called *proof-needles*.

When essayers want to know nearly the proportion of gold and silver in a mass, they rub this mass upon a touchstone, so as to leave a mark upon it. They then make marks upon the touchstone with some of the needles the color of which they think comes nearest to that of the mass. By comparing the marks of these needles with the mark of the mass, they discover nearly the proportion of the gold and silver in the mass.

If this trial shews that in any given mass the silver is not to the gold as three to one, this mass is improper for the operation of parting by aqua fortis. In this case, the quantity of silver necessary to make an alloy of that proportion must be added.

This operation is called *quartation*, probably because it reduces the gold to a fourth part of the whole mass.

2. That the parting may be exact, the nitrous acid or aqua fortis employed must be very pure, and especially free from mixture of vitriolic and marine acids. Its purity must therefore be ascertained, and if this be found not sufficient, the acid must be purified by an operation called the *precipitation of Aqua Fortis*. See that article.

If the purity of the aqua fortis was not attended to, a quantity of silver proportionable to these two foreign acids would be separated during the solution; and this portion of silver, reduced by these acids to vitriol of silver and to luna cornea, would remain mingled with the gold, which consequently would not be entirely purified by the operation.

When

When the metallic mass is properly allayed, it is to be reduced to plates, rolled up spirally, called cornets; or to grains. These are to be put into a matrafs, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the silver as three to two: and as the nitrous acid employed for this operation is rather weak, the solution is assisted, especially at first, by the heat of a sand-bath, in which the matrafs is to be placed. When, notwithstanding the heat, no further mark of solution appears, the aqua fortis charged with silver is to be decanted. Fresh nitrous acid is to be poured into the matrafs, stronger than the former, and in less quantity, which must be boiled on the residuous mass, and decanted as the former. Aqua fortis must even be boiled a third time on the remaining gold, that all the silver may be certainly dissolved. The gold is then to be washed with boiling water. This gold is very pure, if the operation has been performed with due attention. It is called *gold of parting*.

No addition of silver is required, if the quantity of silver of the mass is evidently much more considerable than that of the gold: persons who have not proof needles, and other apparatus to determine the proportion of the alloy, may add to the gold an indeterminate quantity of silver, observing that this quantity be rather too great than too small, and so considerable as to render the mass nearly as white as silver; for a large quantity of silver is rather favorable than hurtful to the operation: It has no other inconvenience than an useless expence, as the larger the quantity is of silver, the more aqua fortis must be employed. We ought to attend to this fact, that the color of gold is scarcely perceptible in a mass two-thirds of which is silver and one-third is gold; this color then must be much less perceptible when the gold is only one-fourth part, or less, of the whole mass.

If the quantity of gold exceeds that of the silver, the mass may be exposed to the action of aqua regia, which would be a kind of inverse parting, because the gold is dissolved in that menstruum, and the silver is not, but rather reduced to a luna cornea, which remains in form of a precipitate after the operation. But this method is not much practised, for the following reasons.

First, the gold cannot be easily separated from the aqua regia; for if the parting has been made with an aqua regia prepared with sal ammoniac, or if the gold be precipitated by a volatile alkali, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia has been made with spirit of salt, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very slow, and probably incomplete. See GOLD (FULMINATING).

Secondly, in the parting by aqua regia, the silver is indeed precipitated into a luna cornea, and thus separated; but this separation is not perfect, as a small quantity of luna cornea will always remain dissolved by the acids, if this solution even could be only effected by the superabundant water of these acids. Accordingly the silver is not so accurately separated from the gold by aqua regia, as the gold is from the silver by aqua fortis. We shall afterwards see, at the article PARTING (CONCENTRATED), that by this operation, silver may be separated from gold without the necessity of quartation, although these metals should not be in a proper proportion for the parting by aqua fortis.

The gold after the parting by aqua fortis is much more easily collected when it remains in small masses, than when it is reduced to a powder.

When the mass has been regularly parted, that is, when it contains three parts of silver and one part of gold, we must employ, particularly for the first solution, an aqua fortis so weakened that heat is required to assist the solution of the silver: by which means the solution is made gently; and the gold which remains preserves the form of the small masses before the solution. If the aqua fortis employed were stronger, the parts of the gold would be disunited and reduced to the form of a powder, from the activity with which the solution would be made.

We may indeed part by aqua fortis a mass containing two parts of silver to one part of gold; but then the aqua fortis must be stronger; and if the solution be not too much hastened, the gold will more easily remain in masses after the operation. In both cases, the gold will be found to be tarnished and blackened, probably from the phlogiston of the nitrous acid. Its parts have no adhesion together, because the silver dissolved from it has left many interstices; and the cornets or grains of this gold will be easily broken, unless they be handled very carefully. To give them more solidity, they are generally put into a test under a muffle and made red-hot, during which operation they contract considerably, and their parts are approximated. These pieces of gold are then found to be rendered much more solid, so that they may be handled without being broken. By this operation also the gold resumes its color and lustre; and as it generally has the figure of cornets, it is called *gold in cornets*, or *grain gold*. Essayers avoid melting it, as they chuse to preserve this form, which shews that it has been parted.

The gold and silver thus operated upon ought to have been previously refined by lead, and freed from all allay of other metallic matters, so that the gold which remains should be as pure as is possible. However, as this is the only metal which resists the action of aqua fortis, it might be purified by parting from all other metallic substances; but this is not generally done for several reasons. First, because the refining by lead is more expeditious and convenient for the separation of the gold from the imperfect metals; and secondly, because the silver, when afterwards separated from the aqua fortis, is pure; lastly, because most imperfect metals do not remain completely and entirely dissolved in nitrous acid, from the portion of phlogiston which this acid deprives them of, the gold would be found after the parting mixed with the part of these metals which is precipitated.

The gold remaining after the parting ought to be well washed, to cleanse it from any of the solution of silver which might adhere to it; and for this purpose distilled water ought to be used, or at least water the purity of which has been ascertained by its not forming a precipitate with a solution of silver, because such a precipitate would alter the purity of the gold.

The silver dissolved in the aqua fortis may be separated either by distillation, in which case all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by some substance which has a greater affinity than this metal with nitrous acid. Copper is generally employed for this purpose at the mint.



The solution of silver is put into copper vessels. The aqua fortis dissolves the copper, and the silver precipitates. When the silver is all precipitated, the new solution is decanted, which is then a solution of copper. The precipitate is to be well washed, and may be melted into an ingot. It is called *parted silver*. When this silver has been obtained from a mass which had been refined by lead, and when it has been well washed from the solution of copper, it is very pure.

Mr. Cramer observes justly in his Treatise on Essaying, that however accurately the operation of parting has been performed, a small portion of silver always remains united with the gold, if the parting has been made by aqua fortis; or a small portion of the gold remains united with the silver, if the parting has been made by aqua regia; and he estimates this small alloy to be from a two hundredth to a hundredth and fiftieth part, which quantity may be considered as nothing for ordinary purposes, but may become sensible in accurate chemical experiments. (z)

(z) The mass of gold and silver to be parted, ought previously to be *granulated*, which may be done by melting it in a crucible, and pouring it into a large vessel full of cold water, while at the same time a rapid circular motion is given to the water by quickly stirring it round with a stick or broom.

The vessels generally used for this operation, called *parting-glasses*, have the form of truncated cones, the bottom being commonly about seven inches wide, the aperture about one or two inches wide, and the height about twelve inches. These glass vessels ought to have been well annealed, and chosen free from flaws; as one of the chief inconveniences attending the operation is, that the glasses are apt to crack, by exposure to cold, and even when touched by the hand. Some operators secure their glasses by a coating. For this purpose they spread a mixture of quicklime flaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the vessel, leaving the upper part uncovered, that they may see the progress of the operation; and over this cloth they apply a composition of clay and hair. Schlutter advises to put the parting-glasses in copper vessels containing some water, and supported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminished by adding cold water, which must be done very carefully by pouring against the sides of the pan, to prevent too sudden an application of cold to the parting-glass. The intention of this contrivance is, that the contents of the glasses, if these should break, may be received by the copper vessel.

Into a glass fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper-pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he usually put about eighty ounces of metal, with twice as much aqua fortis.

The aqua fortis ought to be so strong as to be capable of acting sensibly on silver when cold, but not so strong as to act violently. If the aqua fortis be very strong, however pure, and if the vessels be well closed, a small quantity of the gold will be dissolved along with the silver, which is to be guarded against.

Little heat ought to be applied at the beginning, the liquor being apt to swell and rise over the vessel; but when the acid is nearly saturated, the heat may be safely increased.

When the solution ceases, which may be known by the discontinuance of the effervescence, or emission of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis must be added, that all the silver may be dissolved. If the operation has been performed slowly, the remaining gold will have still the form of distinct masses, which are to receive solidity and color by fire, in the manner directed by the author of the Dictionary. If the operation has been performed hastily, the gold will have the appearance of a black mud or powder, which after five or six washings with pure water must be melted.

The silver is usually recovered by precipitating it from the aqua fortis by means of copper-vessels into which the liquor is poured,

**DCXXV. PARTING (CONCENTRATED).** Concentrated parting is also called *parting by cementation*, because it is actually performed by cementation. This parting or purification of gold is used when the quantity of it is so great in proportion to the silver, that it cannot be separated by aqua fortis. This operation is done in the following manner.

A cement is first prepared composed of four parts of bricks powdered and sifted, of one part of green vitriol calcined till it becomes red, and of one part of common salt. The whole is very accurately mixed together, and a firm paste is made of it by moistening it with a little water or urine. This cement is called *cement royal*, because it is employed to purify gold, which is considered by chemists as the king of metals.

The gold to be cemented is to be reduced to plates as thin as small pieces of money. At the bottom of the crucible or cementing-pot, a stratum of cement, of the thickness of a finger, is to be put, which is to be covered with plates of gold; upon these another stratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with these alternate strata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and sand. This pot is to be placed in a furnace, or oven, and heated by degrees till it is moderately red, which heat is to be continued during 24 hours. The heat must not be so great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully separated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be essayed upon a touchstone or otherwise; and if it be found not sufficiently purified, it is to be cemented a second time in the same manner.

The vitriolic acid of the bricks and of the calcined vitriol disengages the acid of the common salt during this cementation: and this latter acid dissolves the silver alloyed with the gold, and separates it by that means.

This experiment proves, that although marine acid, while it is liquid, cannot attack silver, it is nevertheless a powerful solvent of that metal. But for this purpose it must be applied to the silver in the state of vapors, extremely concentrated, and assisted with a considerable heat. All these circumstances are united in the concentrated parting.

This experiment proves also, that notwithstanding all these circumstances, which favour the action of the marine acid, it is incapable of dissolving gold.

Lastly, the marine acid in this state more effectually dissolves the silver than the nitrous acid does in the parting by aqua fortis, since this operation succeeds

or of plates of copper which are thrown along with the liquor into glass-vessels. A considerable heat is required to accelerate this precipitation. Dr. Lewis says, he has observed that when the aqua fortis was perfectly saturated with silver, no precipitation was occasioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as usual.

The precipitated silver must be well washed in boiling water, and fused with some nitre, the use of which is to scorify any cupreous particles, which may adhere to the silver.

From the solution of copper in aqua fortis, a blue pigment called *verditer* is obtained by precipitation with whiting. See **VERDITER**.

well

well when the silver is in so small a proportion as that it would be protected from the action of the nitrous acid in the ordinary parting.

Instead of sea salt, nitre may be used with equal success; because the nitrous acid is then put in a state to attack the silver, notwithstanding the quantity of gold which covers it.

Several chemists and artists use both nitre and common salt in the cement royal; which shews that the acids of aqua regia, applied in this manner at the same time to gold and to silver, attack the latter metal preferably to the former. (a)

The gold must be very carefully washed after the operation to cleanse it from particles of dissolved silver, which otherwise would stick to it.

The silver may be separated from the cement by fusion with a sufficient quantity of lead and litharge, and by cupelling the lead which retains the silver. (b)

**DXCVIII. PARTING (DRY).** Dry parting, or parting by fusion, is performed by sulphur, which has the property of uniting easily with silver, while it does not attack gold.

This method of separating these two metals would be the cheapest, the most expeditious and convenient of any, if the sulphur could dissolve the silver, and separate it from the gold as well and as easily as nitrous acid does; but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the sulphur with the silver allayed with gold. Then repeated and troublesome fusions must be made, in each of which we are obliged to add different intermediate substances, and particularly the metals which have the strongest affinity with sulphur, to assist the precipitation, which in that case does not give a regulus of pure gold, but a gold still allayed with much silver, and even with a part of the precipitating metals; so that, to complete the operation, cupellation is necessary, and also parting by aqua fortis.

From what we have said concerning this operation we may perceive, that it ought not to be made but when the quantity of silver with which the gold is allayed is so great, that the quantity of gold which might be obtained by the ordinary parting is not sufficient to pay the expences; and that it is only proper for concentrating a larger quantity of gold in a smaller quantity of silver. As this dry parting is troublesome, and even expensive, it ought not to be undertaken but on a considerable quantity of silver allayed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemists and artists who have given processes for the dry parting, recommend its use only in the above-mentioned cases. We wish that this operation could be improved: it would be much more advantageous, if it could be done by two or three fusions; and if by

(a) By this method some of the gold would probably be dissolved along with the silver. As no advantages are said to attend it, to give it preference to cementation with nitre or with sea salt singly, Dr. Lewis does judiciously, I think, disapprove of it.

(b) Gold is never purified by one operation of this kind. It must therefore be

again melted, beat into plates, and cemented as before. The operation is troublesome, and is now little used, excepting, as Dr. Lewis says, for extracting silver or base metals from the surface of gold, and thus giving to an alloyed metal the color and appearance of pure gold.

these an exact separation could be obtained of a small quantity of gold mixed with a large quantity of silver. (c)

Under the article *PURIFICATION of GOLD by ANTIMONY*, we shall see that this purification is a true dry parting, and we shall there find the theory of what passes in that operation.

(c) As this operation for extracting a small quantity of gold from a large quantity of silver is, notwithstanding its inconveniences, approved by Schlutter, Scheffer, and other authors, and practised in Hartz, we shall add to the article in the Dictionary concerning it, what Dr. Lewis, in his excellent History of Gold, has said upon the subject.

The most advantageous method of separating a small portion of gold from a large one of silver appears to be by means of sulphur, which unites with and scorifies the silver without affecting the gold: but as sulphurated silver does not flow thin enough to suffer the small particles of gold diffused through it to reunite and settle at the bottom, some addition is necessary for collecting and carrying them down.

In order to the commixture with the sulphur, fifty or sixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a small crucible made red-hot, and pouring it into cold water stirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, according as it is richer or poorer in gold, is reserved; and the rest well mingled with an eighth of powdered sulphur. The grains enveloped with the sulphur are again put upon the crucible, and the fire kept gentle for some time, that the silver, before it melts, may be thoroughly penetrated by the sulphur; if the fire was hastily urged, great part of the sulphur would be dissipated, without acting upon the metal.

If to sulphurated silver in fusion pure silver be added, the latter falls to the bottom, and forms there a distinct fluid, not miscible with the other. The particles of gold, having no affinity with the sulphurated silver, join themselves to the pure silver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or less perfectly according as the pure silver was more or less thoroughly diffused

through the mixed. It is for this use that a part of the granulated metal was reserved. The sulphurated mass being brought into perfect fusion, and kept melted for near an hour in a close covered crucible, one third of the reserved grains is thrown in; and as soon as this is melted, the whole is well stirred, that the fresh silver may be distributed through the mixed, to collect the gold from it. The stirring is performed with a wooden rod; an iron one would be corroded by the sulphur, so as to deprive the mixed of its due quantity of sulphur, and likewise render the subsequent purification of the silver more troublesome. The fusion being continued an hour longer, another third of the unsulphurated grains is added, and an hour after this the remainder; after which the fusion is further continued for some time, the matter being stirred at least every half hour from the beginning to the end, and the crucible kept closely covered in the intervals.

The sulphurated silver appears in fusion of a dark brown color: after it has been kept melted for a certain time, a part of the sulphur having escaped from the top, the surface becomes white, and some bright drops of silver, about the size of peas, are perceived on it. When this happens, which is commonly in about three hours after the last addition of the reserved grains, sooner or later according as the crucible has been more or less closely covered, and the matter more or less stirred, the fire must be immediately discontinued, for otherwise more and more of the silver, thus freed from its sulphur, would sublime and be lost. The part at the bottom is then lifted out with a small crucible, and the rest poured into the mortar. The gold, diffused at first through the whole mass, is now found collected into a part of it at the bottom, amounting only to about as much as

**DEXXIX. PELICAN.** The pelican is a glass alembic consisting of one piece. It has a tubulated caput, from which two opposite and crooked beaks pass out, and enter again at the belly of the cucurbit. This vessel has been contrived for a continued distillation and sublimation, which chemists call *circulation*. The volatile parts of substances put into this vessel rise into the caput, and are obliged to descend through the crooked beaks into the cucurbit; and this without interruption, continuing and circulating the vessels.

Although the pelican seems to be a very convenient instrument, it is nevertheless little used, and even much neglected at present, either because the modern chemists have not so much patience as the ancient chemists had, for making long experiments; or because they find that two matrasses, the mouth of one of which is inserted into the mouth of the other, produce the same effect. See *PLATE I.*

**DEXXX. PELlicLE.** By this word chemists mean a very thin saline crust, which is formed upon the surfaces or solutions of salts, when they are evaporated to a certain degree. This pellicle is nothing else than a number of saline particles crystallized by evaporation at the surface of the liquor rather than any where else, because the evaporation is made there. These small crystals of salt at first cover the surface of the liquor, and give it a dusky ap-

pearance, which is called *infumation*. This part may be separated from the evaporated liquor, either by a chisel and hammer, or more perfectly, the surface of the liquor being generally raised and stirred, by stirring the whole mass with the bottom upwards in a crucible. The infumation very quickly melts, leaving underneath this what contains the gold, which may thus be separated, separated from the silver. The silver and silver is cleared, by keeping a portion of it in fusion in an open crucible, till the sulphur is dissipated, and then dissolving it in aqua fortis. If it should still be found to contain any gold, it may be melted again, as much more unimpregnated silver may be added as was employed in each of the former calcinations, and the fusion repeated about an hour and a half.

The gold thus collected may be part of the silver may be further concentrated into a smaller mass, by dissolving the mass and evaporating the liquor again. The operation may be repeated till the gold is reduced to about half the weight of the silver, and the silver may be melted again, and the gold collected as before.

The gold thus collected may be part of the silver may be further concentrated into a smaller mass, by dissolving the mass and evaporating the liquor again. The operation may be repeated till the gold is reduced to about half the weight of the silver, and the silver may be melted again, and the gold collected as before.

of lead is almost forty pounds on a quintal or hundred pounds of the ore. The lead worked off on a less or caper-search yields about a hundred and ten grains of silver, and the silver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting scarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above-mentioned compares this method of separation to fish silver as it does in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a fifty-fourth of the silver, he advises the use of aqua fortis for concentrating the gold the far, as a portion of it will always be taken up with the silver. Mr. Scheffer, however, relates in the Swedish Memoirs for the year 1741, that he has by this method obtained the gold in perfect fineness; and that he has likewise collected all the gold which the silver contained, the silver of all his operations, which had taken up a portion of the gold, being reserved to be worked over again with a fresh quantity of aqua fortis. The highest price they in Europe pay for concentrating it is about for four shillings with a great further expense to the art; the sulphur gradually remains, and forms the silver matter.

pearance, as if it were covered with dust or with a very thin skin, from which appearance the name of pellicle has been given.

As all crystallizable salts may be crystallized by evaporation alone, in the solution therefore of any of these salts a pellicle may be formed; and also, as all solutions of salts, evaporated till a pellicle is formed, furnish crystals by exposing the liquor to cold, chemists have established a general rule for crystallization, to evaporate solutions of salts till a pellicle is formed, and then to leave them to crystallize by exposure to cold.

This rule is applicable to many salts, but is not general; for some salts, as common salt, do not crystallize by exposure to cold, although the solution of them has been previously evaporated till a pellicle has been formed; while other salts, as nitre and Glauber's salt, may be crystallized in great quantities, although their solutions have not been evaporated so much as that a pellicle has been formed. Hence, to crystallize such salts as common salt, the evaporation must be continued after the pellicle has been formed; and to obtain fine crystals of nitre, Glauber's salt, and others which crystallize in a similar manner, the evaporation must not be continued till a pellicle is formed, but their solutions must be left to cool slowly before it has been so much evaporated. See CRYSTALLIZATION of SALTS

DXXXI. P E N N Y - W E I G H T S. Penny-weights are fictitious parts into which we suppose any mass of silver to be divided, to specify its degree of purity.

Any mass of silver, the purity of which is to be examined, is supposed to consist of twelve equal parts called penny-weights; and if the silver be perfectly fine, and contain no alloy, then the twelve parts of the mass are all of pure silver, and this silver is said to be *silver of twelve penny-weights*. If the mass of silver contain a twelfth part of alloy, it will then contain only eleven parts of pure silver, and it will be called *silver of eleven penny-weights*, &c.

To expose more precisely the value of silver, each penny-weight is subdivided into twenty four grains. (d)

DXXXII. P E P P E R. (e)

(d) A penny-weight is also a real weight used in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

(e) PEPPER. Neumann says, that *Pimento*, or *Jamaica Pepper*, appears from a chemical examination to contain, 1. An indissoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drams and a scruple in an ounce. 2. Gummy, or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at first gave two drams and two grains of gummy extract; and another ounce, freed by rectified spirit from all that the menstruum could dissolve, yielded still with water five scruples of mucilage. 3. A resinous substance in smaller quantity.

The resinous extract obtained by applying rectified spirit at first, amounted to only one dram and six grains from an ounce; an ounce freed from its mucilaginous matter by coction in water, yielded of pure resin no more than one scruple. 4. An essential oil in still smaller quantity; of this principle an ounce of pepper contains scarcely half a dram.

Upon examining the qualities of the several products, it appeared, that the oil is the principal and characteristic part, containing all the smell and the aromatic flavor, though not the pungency of the berry. As the prevailing flavor of pimento approaches that of cloves, the oil also greatly resembles the genuine oil of cloves. It has the same kind of smell and taste, discovers no green heat or pungency, and is so heavy as to sink in water.

DXXXIII. PERUVIAN-BARK. (f)

DXXXIV. PETROLEUM. See BITUMEN.

DXXXV. PETUNTSE. (g)

DXXXV. PHLEGM. Chemists have given the name *Phlegm* to the most watery part obtained from bodies by distillation or otherwise.

Phlegm is frequently water mixed superabundantly, and not combined in the bodies from which it is obtained. Such are the phlegms obtained by dis-

water: to which may be added, that the oil of pimento, like that of cloves, resides chiefly in the shell or cortical part, the internal substance yielding little or none. 2. That the heat and pungency are lodged in the resin. In this respect also pimento agrees with cloves: but as pimento in substance is far less hot and fiery than cloves, its resin is also more mild. 3. That the gummy parts have very little activity.

Rectified spirit of wine elevates nothing from this spice in distillation, the oil of pimento being too ponderous to rise with so light a fluid. The only way of making a spirit from it is to dissolve some of the oil in pure spirit of wine. An agreeable spirituous water may be made with proof spirit, the watery phlegm in that liquor carrying up a part of the oil.

The *black pepper* of the East Indies contains an essential oil which has a strong and durable smell, and a taste the mildest of all essential oils. This oil is partly elevated in distillation by rectified spirit of wine; which thereby acquires the flavor, but none of the pungency, of the pepper. The spirituous extract is excessively fiery. The watery extract is also very hot and biting. Neither this menstruum nor the spirit can, singly, extract all the hot matter of the pepper.

Sixteen ounces of black pepper yielded with water ten ounces of gummy extract, and afterwards with rectified spirit three drams of resin: another pound, treated first with spirit, gave two ounces and two drams of resinous extract; and afterwards, with water, seven ounces four drams and two scruples of gummy matter. This last extract had still some degree of pungency, rectified spirit seeming not to take up all the active parts any more than water. Of essential oil, about two drams and a half may be obtained from a pound.

*White pepper* has the same kind of taste and flavor as the black, but in a much less degree. It agrees also with the black in the

nature of its chemical principles; and is, in effect, the same kind of fruit gathered before it is grown fully ripe, and freed from the outer skin. *Neuman*.

(f) PERUVIAN BARK. *Neuman* says, that from a pound of Peruvian bark rectified spirit extracted ten drams and two scruples of resinous matter; and that water extracted from the residuum five drams of gummy matter. He says also, that by applying water first, and afterwards spirit, to the residuum, seven drams and a scruple of gummy matter, and six drams of resinous matter were extracted. To this Dr. Lewis adds the following note. See his edition of *Neuman's Works*.

"Different sorts of Peruvian bark differ considerably in their yield of extract. Those which I examined afforded a much larger quantity of resinous extract than *Neuman* obtained from his.

"It is observable of this drug, says he, that its astringency resides wholly in the resin, which does not appear to be in any degree soluble in watery liquors, but its bitterness in a gummy-resinous substance, or such a one as is soluble both in water or in spirit. Both principles may be extracted by boiling in water, the resin melting out by the heat, and rendering the liquor turbid. The decoction in this state tastes astringent as well as bitter; but on standing it deposits the resin and becomes clear, and then proves simply bitter. Repeated coction and large quantities of water are necessary for extracting all the virtues of the bark: the resin melts out in the first boilings: the decoctions made afterwards are transparent and bitter, without the least turbidness or astringency."

(g) PETUNTSE. This is the Chinese name given to a stone which is one of the ingredients of oriental porcelain. It is said to be white, fusible by fire, to give phosphoric light when rubbed, and to have the other properties of the stones called fluors. See PORCELAIN.



tillation with the heat of a water-bath, from all those vegetable and animal matters which contain no principle so volatile as to rise with a less heat than that of boiling water. These phlegms, which are produced merely by drying, are nothing but water almost pure, that is, the water of vegetation: but a phlegm consisting of water which had been combined in any body, as, for instance, the phlegm obtained in the distillation of oils, is far from being a pure water. It is still mixed and even united with a sensible quantity of the principles of the body, and requires further operations, and chiefly the assistance of intermediate substances, to separate it perfectly.

Neither is that phlegm pure water, which, though it is superabundant, yet adheres to certain substances, especially to those that are volatile. Such are liquid volatile alkalis, and most alkalis. By distillation we may separate a considerable quantity of their phlegm or superabundant water, which operation is called *dephlegmation*: but this phlegm contains always a certain quantity of the saline matters with which it was originally mixed.

Hence we may see that the word *Phlegm* signifies in general the most watery part separated from several bodies, but that it is rarely pure water; and that phlegms differ from each other according to the nature of the substances from which they are obtained.

DXXXVI. P H L O G I S T O N. By *phlogiston* chemists mean the most pure and simple inflammable principle.

Amongst the various natural bodies, some have been observed to be capable, by exposure to fire with the concurrence of air, of being kindled, of producing flame, of augmenting the fire, and of maintaining and supporting it; while other bodies, by exposure to fire, do indeed become hot, red, and luminous; but are incapable of producing flame, or of maintaining fire. These latter substances do not burn, but only are penetrated by a foreign fire, and cease to be hot and luminous, when this extraneous fire is removed from them.

These bodies are distinguished from each other by calling the former *combustible bodies*, and the latter *incombustible*. Chemists have always made a great distinction betwixt these two kinds of bodies, and have perceived that the inflammability of the former was caused by a principle which did not exist in the latter: but as this inflammable principle cannot be separated from the other principles of bodies, nor be obtained pure; and, consequently, as it is impossible to discover all the properties which are peculiar to it, and which distinguish it from all other substances, the ancient chemists had very confused notions of this inflammable principle; and even now, notwithstanding all the sagacity of the greatest modern chemists, this is, of all the principles of bodies, the least accurately known.

The great error of ancient chemists was, in not sufficiently distinguishing this principle from other more compound bodies, which indeed contain much of it, but of which it is only a constituent part. For instance, they confounded it with oil and with sulphur, the names of which substances were indiscriminately given to it, although neither oil nor sulphur be the phlogiston of the moderns, but are only substances into the composition of which a great quantity of this principle enters.

On the other hand, as oil, sulphur, and other inflammable matters, differ so much from each other that they cannot be considered as the same thing, probably



bably the ancients, who sometimes gave it one and sometimes another of the names of these inflammable compounds, mistook its unity and identity; that is, they did not know that one only inflammable principle exists, always the same, always similar to itself, either in oils, or in sulphur, or in coals, in a word, in any combustible whatever. We owe the knowledge of these important truths to modern chemists, and particularly to the illustrious Stahl, who has created in some measure a new chemistry, and entirely changed the appearance of this science. All that we shall say concerning phlogiston or fire as a principle of bodies shall be the grounds of the doctrine of that chemist concerning this important matter.\* To that we shall only add some observations resulting from an attentive examination of the phenomena.

Phlogiston ought to be considered as elementary fire combined, and rendered one of the principles of combustible bodies.

The principal phenomena exhibited by combustible bodies are to kindle, to excite heat and light, to produce the same effects upon other bodies as are produced by the solar rays united in a focus, or by the friction of hard bodies. All these bodies may be inflamed or put into an igneous state by the touch of pure fire rendered active, or, which is the same thing, by the contact of any body actually in the state of ignition.

The combustion of bodies occasions a decomposition and separation of their component principles; and the phenomena of combustion subsist more or less sensibly, till the fire which entered into their composition as a principle be entirely disengaged, exhausted, or dissipated. What remains afterwards of the burnt body belongs to the class of incombustibles. These phenomena leave no doubt that elementary fire enters as a principle into the composition of these bodies. *See COMBUSTION.*

Boerhaave thinks that combustible bodies are not changed into elementary fire during their combustion; because, says he, if it were so, the element of fire would be infinitely increased: but we may reply, that this event would not happen if this fire, thus disengaged from bodies, be capable of entering into new combinations, and of forming new inflammable bodies; but, from the same reason that it entered into the composition of the first combustible bodies, it may also enter into new similar combinations. Thus, fire continually circulates, like the other elements, which are sometimes pure, free, disengaged from all bodies, and capable of exhibiting all their properties, and sometimes are combined, united with other bodies, and forming compounds in which their properties are more or less disguised and modified by those of the other principles with which they are united; and thus these elements pass alternately in the continued operations of nature from one of these states to the other.

We cannot indeed easily conceive how pure elementary fire, whose parts appear always agitated by a violent motion, and deprived of all cohesion, or of any disposition to adhere in a fixed manner to the parts of other bodies (*see FIRE*) should join, as a principle, in so constant and solid a manner; that is, that each of its primary integrant parts should so strongly unite and adhere to each of the primary integrant parts of any solid body, that it should become deprived of fluidity, mobility, and of almost all the activity which is essential to it. We nevertheless see, from all the chemical phenomena, that the nature and quantity of contact of the integrant and constituent parts of bodies are  
capable

capable of producing the most surprizing unions and combinations. Facts also demonstrate, that this union of the parts of fire with other bodies really exists; for otherwise we cannot conceive the phenomena of combustible bodies.

The phlogiston, then, or inflammable principle of modern chemists, can be nothing else than the purest and simplest fire, considered in its state of combination, and not in that of aggregation: but we do not yet know whether pure fire be susceptible of combining without any intermediate substance with all the bodies with which we find it united; or whether it cannot enter into these combinations, but by the assistance of an union previously contracted with some substance more disposed than others to combine with it, by means of which it is then rendered capable of entering into all the compounds in which we find it. If this be the case, phlogiston is not pure elementary fire, but this element previously combined with another, and is only a secondary principle. Reasons may be given for and against these opinions, which we shall mention.

First, we shall observe, that chemists have not been able to separate and procure alone what they call the *inflammable principle of bodies*, although they can easily enough procure the other secondary principles. They have only been able to disengage it from bodies by combustion, and then it necessarily resumes the state of pure and active fire, which is well known to be incoercible; or else it is taken from one body by means of another applied to it, with which it unites as soon as it quits the former. In this second case, it is indeed separated from a body without combustion, and without reducing it to actual fire; but it is not obtained alone and pure, since it only quits one combination to enter at the same time into another.

This difficulty, hitherto not surmounted, of obtaining the inflammable principle of bodies in any other state than that of free and active fire, appears to us one of the strongest reasons for believing that phlogiston is nothing else than pure fire, but deprived of its activity by the union it contracts with any substance. If this be the case, phlogiston has no other properties than those of pure fire; or, to speak more accurately, it has no other, as phlogiston, than those which arise from the union of pure fire with the several substances with which it is united. These properties are then peculiar to each of these combinations, and different according to the nature of the substances combined with fire.

However that may be, the power which chemists have of transferring the inflammable principle from one combination to another, with combustion and dissipation, has furnished them with the means of making most important observations on the effects which it produces in many chemical operations, and of remarking the properties which it communicates to the several substances with which it unites. They have compared the properties of a body furnished with its inflammable principle, with those of this same body when deprived of this principle. They have examined the new properties of substances with which they have been able to combine phlogiston. By observing this principle in its progress from one combination to another, and by thus tracing it, Becher, who called it *inflammable earth*, and Stahl, who called it the *principle of inflammability* or *phlogiston*, have been able to give us much light concerning the nature of this substance, which acts so powerfully in almost all the operations of chemistry

The observations of these chemists, and of some others since their time, have taught us several general properties of phlogiston, which we shall first relate briefly, without endeavouring to explain them, that they all may be seen at once collected, and from one point of view. Besides, these truths will be sufficiently illustrated and proved by the particular relation of the phenomena exhibited by phlogiston in the several experiments of chemistry, which we shall have occasion to describe.

When phlogiston is united with an unflammable substance, a new compound results, which is neither hot nor luminous; but which becomes, by that union, inflammable, and capable of producing heat and light more or less easily according to the quantity of phlogiston united with this new compound, and according to the manner in which it is combined.

The principle of fire, by uniting with bodies naturally solid, does not render them fluid, but diminishes their hardness, and renders them more fusible.

Also the compound formed by the union of the inflammable principle with a fixed body is rendered less fixed than it was before that union.

It increases the absolute gravity, and frequently the specific gravity of bodies into which it enters; and in some cases it renders them opaque.

Substances which have neither smell nor color, acquire generally one or the other, and frequently both, by their union with the inflammable principle; and hence chemists have been inclined to consider it as the principle of colors and smells. Some bodies indeed, which contain phlogiston, have neither any sensible color or smell. But, first, we can prove, that these bodies contain but a very small quantity of phlogiston; and, secondly, we know no body which contains a large quantity of this principle, which has not more or less of color and of smell.

Although the compounds in which phlogiston enters are often very different from each other, yet this principle is not of various kinds, but is always identically the same, and similar to itself, of whatever nature the bodies may be to which it is united.

Phlogiston is not equally disposed to unite with all substances. It combines very difficultly with fluid, volatile, and light matters, such as air and water: perhaps even it never unites with these but by means of some intermediate substance; on the contrary, it may be easily combined with solid, fixed, and heavy substances, as earths.

Phlogiston frequently serves as an intermediate substance to unite together bodies incapable of uniting, or very difficultly without it.

We know of no direct combination of phlogiston with either air or water, that is, we know no body composed solely of phlogiston and air, or of phlogiston and water. But this principle is capable of combining with compounds of which water is a principle: such are oily and saline substances, and particularly vitriolic acid and nitrous acids.

The vitriolic acid cannot unite intimately with phlogiston unless it be dry, that is, unless it be deprived of all water superabundant to its saline essence, extremely concentrated, and contain no water but that which is a principle or constituent part of it. From this union an inflammable compound is formed called *sulphur*. Vitriolic acid in this state quits all bodies to unite with phlogiston, with which it forms sulphur; and the sulphur is always exactly alike,

from

from whatever body the phlogiston has been transferred. Thus, whether an oil, resin, fat, coal, or metal, be treated with vitriolic acid, the same sulphur is formed; and since with the same acid all inflammable bodies produce the same compound, therefore the phlogiston of these bodies, however different they may be from each other, is necessarily the same, and consequently this principle is single and identical.

The inflammability of sulphur is caused by the phlogiston it contains; but its flame is not very luminous and ardent; because it contains more vitriolic acid, which is incombustible, than phlogiston.

Sulphur is decomposed by the burning of its phlogiston, which becomes disengaged fire, and dissipates. The vitriolic acid also becomes disengaged, pure, and capable of combining with the phlogiston of another body to form sulphur again, entirely similar to the former.

The vitriolic acid of sulphur is united to phlogiston only, since this acid contains no superabundant water, and also as it is demonstrated that the combustible bodies treated with this acid to form sulphur give it nothing but pure phlogiston. We may therefore discover several of the properties of this principle by comparing sulphur with pure vitriolic acid. The vitriolic acid, which has neither smell nor color when it is pure, forms with phlogiston a compound possessing both these qualities, which are even capable of being rendered much more sensible in some circumstances; as for example, in the combination of liver of sulphur. In the second place, although we cannot certainly know if sulphur be more or less volatile than pure vitriolic acid, because we cannot ever obtain this acid disengaged, without containing at the same time much superabundant water, even when it is in a concrete and glacial form; we have reason, nevertheless, to believe, that sulphur is more volatile than pure vitriolic acid, and that this greater volatility it receives from the phlogiston. This, at least, is evidently indicated by the volatility of sulphureous vitriolic acid, which is infinitely greater than that of simple vitriolic acid.

In the third place, although the disengaged vitriolic acid, particularly when much concentrated, is extremely greedy of moisture, and much more so when deprived of all superabundant water; and although the quantity of this acid be much greater than that of phlogiston in sulphur; yet we see, nevertheless, that sulphur is not soluble in water, which can only be attributed to its phlogiston. This difficulty of uniting with water is common to all the other combinations in which phlogiston is intimately and abundantly combined: for which reason, vitriolic acid cannot form sulphur, unless it be deprived of all superabundant water. This character of dryness, and aversion to unite with water, which the principle of fire preserves in all its combinations, has inclined Beccher to consider it as a principle of a *dry, earthy nature*, and to call it *inflammable earth*, thus signifying an opposition of properties to those of water. We shall not examine now whether Beccher justly made this distinction betwixt what he called a dry and earthy quality, and the humid and aqueous quality; as water is only kept fluid and humid by being penetrated with a certain quantity of disengaged fire, and appears, when deprived of fire, to be as dry and solid as the substances called earthy: but this is certain, that although water perhaps may be essentially as dry as fire, yet these two are of very different natures, and have very little disposition to unite and combine intimately.

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When sulphur is decomposed by burning, its acid greedily seizes moisture, as soon as it is disengaged : but as all the phlogiston does frequently not burn, particularly when the combustion is slow, a small portion of it remains still united with the aqueous acid. This small quantity of phlogiston adheres very weakly to the sulphureous acid, and easily separates from it without fire, and merely by exposure to air : but while it remains united, it communicates properties very different from those which the acid possesses when pure. The acid is rendered much more volatile ; it acquires a pungent, suffocating, and insupportable smell ; and, lastly, its strength, or its adhesion to those bodies with which it is capable of uniting, is greatly diminished. It is then called *volatile sulphureous acid*.

We may observe, that although vitriolic acid has a great affinity with phlogiston, the presence of water prevents the intimate union of these two substances. Hence, when vitriolic acid is combined with inflammable matters, if any water be contained either in the acid or in the inflammable matter, not sulphur, but a volatile sulphureous acid will be formed. Sometimes indeed true sulphur is formed even in liquors, and by the humid way ; but by some means the vitriolic acid and the inflammable principle must be separated from all superabundant water, else the intimate union by which sulphur is formed, will not happen. See ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), SULPHUR, and LIVER of SULPHUR.

Phlogiston has also a strong affinity with nitrous acid, even stronger than with the vitriolic, as we shall see from the following facts. For, first, the volatility of the nitrous acid, its color, its smell, its inferiority of strength compared with vitriolic acid ; lastly, its inflammability, and its total decomposition by inflammation, prove, that phlogiston enters into the composition of this acid, and is one of its constituent parts. Stahl and most chemists think, and with much probability, that nitrous acid differs only from the vitriolic by its containing phlogiston.

In the second place, nitrous acid acts more strongly in general than vitriolic acid upon all compounds which contain the inflammable principle, and deprives them more effectually of this principle, as is peculiarly observable in solutions of metals. Besides, nitrous acid seems to act nearly as vitriolic acid does with regard to its combinations with a quantity of phlogiston superabundant to its composition ; but some differences may be perceived, which ought to be attributed to the inflammable principle which makes part of its combination. Like the vitriolic acid, it cannot unite with phlogiston in the most intimate manner, unless it be in a dry state : it then forms a kind of sulphur which may be called *nitrous sulphur*, which, from the phlogiston already contained in the acid, is so inflammable, that it kindles as soon as it is formed, and therefore has never been obtained alone and uninflamed, as we obtain the vitriolic sulphur. See upon this subject DETONATION of NITRE.

When the nitrous acid contains superabundant water, it still acts very powerfully upon the phlogiston of most bodies ; but no inflammation happens, excepting that during the act of combination, the phlogiston and acid can be rendered dry ; without which circumstance, only a superficial and weak union of these two substances can be made. The aqueous nitrous acid does indeed attract phlogiston superabundantly, by which its color, smell, and volatility, are

considerably increased; of which we see very evident examples in the solutions of almost all metallic matters by this acid, as of iron, zinc, copper, tin, &c. But then this phlogiston adheres but weakly to the acid, because of the water of the acid, as it does, for the same reason, to the volatile sulphureous acid; and it separates, without heat, by mere exposure to air.

Altho' nitrous acid be probably capable of thus attracting superabundantly a larger quantity of phlogiston than vitriolic acid, we do not observe, nevertheless, that this superabundant phlogiston produces such a change upon the nitrous acid, as it does upon the pure vitriolic, when it converts this latter into the volatile sulphureous acid. The cause of this evidently is, that nitrous acid in its natural state contains already so considerable a quantity of phlogiston as one of its principles, that it has in a certain degree all the properties of a phlogisticated acid; and these qualities ought not to be changed, but only rendered more sensible by the addition of a superabundant quantity of phlogiston: whereas the vitriolic acid in its pure state, not containing any phlogiston, or at least not sensibly, must, by such an addition, pass from the state of an unphlogisticated acid to that of an acid united with the inflammable principle, when from a pure vitriolic acid it becomes a volatile sulphureous acid, by which it is rendered entirely different. This seems to me to be one of the best proofs that nitrous acid contains phlogiston as a principle and constituent part. See ACID (NITROUS).

As the acid of common salt has smell, color, and particularly much volatility, it seems provided with all the properties of an acid united with the inflammable principle. Nevertheless, we do not see that it has the same disposition as the vitriolic and nitrous acids to combine itself with this principle, neither intimately, nor even superficially. On the contrary, it is incapable of acting upon many inflammable matters, for instance, oils; it acts more weakly upon metals, deprives them of less of their inflammable principle, and adheres to them more strongly than the other two mineral acids. Lastly, we do not know any immediate combination of marine acid with phlogiston, that is, any *marine phlogiston*; for the phosphorus of Kunckel, which has been believed to be such by Stahl and other chemists, is not a marine sulphur, as we shall see in its place. From what cause then do properties so contradictory proceed? We know too little of the true nature of the marine acid, and of the principle which distinguishes it from the other acids, to be capable of saying any thing satisfactory on this subject. According to Beccher, the mercurial earth distinguishes this acid from the others. If this be true, the union of phlogiston with marine acid is prevented by this earth. But, on the other side, this earth appears to have many of the properties of phlogiston, both from the properties of marine acid, and from those of metals, which also are supposed to contain mercurial earth: or, is not this union of phlogiston with marine acid prevented by a certain modification of the phlogiston itself contained in that acid, by which its nature is in some measure changed, as Henckel seems inclined to think? Let us hope for further illustration of this obscure matter from time, experience, and the advancement of chemistry. See ACID (MARINE).

Fixed alkalis shew in many experiments a considerable disposition to unite with phlogiston. Their properties shew even that this principle is one of their constituent parts; nevertheless, they seem to have less affinity with phlogiston

giston than the vitriolic and nitrous acids, or even than metallic earths. The phenomena exhibited by them when united with inflammable matter have not been sufficiently examined. In some cases, they acquire a very quick and pungent smell, and extreme volatility, as when they are changed into volatile alkali; which happens, as is known, by combining and distilling them with fat matters. In other cases, they may be saturated with an inflammable matter, with which they appear to be intimately united, although they do not acquire the smell and volatility of *volatile alkali*. This happens when they are calcined in close vessels with coals, as in the preparation of the saponaceous alkali for the Prussian blue. Are these two combinations of alkali with phlogiston any thing similar to the combinations of the vitriolic and nitrous acids with the same principle? I am inclined to believe so; but this matter requires further examination. See ALKALI (FIXED).

Phlogiston then appears to have a strong disposition to unite with dry and earthy matters, and to adhere to them strongly: but notwithstanding this disposition, we cannot make this combination with any given proportions of these matters, nor with any of the substances containing phlogiston. I do not know that phlogiston would quit the vitriolic acid or metals to unite with a simple earth: we have no reason to presume that this could be effected, unless perhaps by very nice and difficult processes. This is certain, that although these researches be very interesting, as they are connected with the theory of the composition of metals which seem to be formed of earth and phlogiston, they have not been ever made; or, at least, the attempts of chemists upon this subject have not been distinctly published. See METALS and METALLIZATION.

Several kinds of earths, particularly those the parts of which are naturally very fine and much divided, such as calcareous, and more especially argillaceous earths, appear the fittest to be united with the inflammable principle; and further, phlogiston seems to be most disposed to unite with these earths when it is in the state of oil, of soot, or of vapors. Accordingly, when calcareous or argillaceous earths have been mixed with fat matters, and have afterwards been exposed to the action of fire in close vessels, they retain much of the phlogiston of these matters, which adheres strongly, and communicates color to them, particularly shades of blackness, which cannot afterwards be separated but by a very long calcination in an open fire. In Mr. Macquer's *Memoir upon Clays*, we may see, that when these earths are exposed to violent fire, although many of them be naturally white, and others become white by a moderate heat, they all acquire colors when exposed to violent fire, apparently from contact of phlogistic vapors; and that these colors, which are black, grey, yellow, greenish or bluish, remain obstinately without any possibility of destroying them. See CLAYS.

The coals of vegetable and animal matters are nothing else than singular combinations of the earthy part of these organized bodies with the inflammable principle of their oils and fat. All the properties of coals shew us, that although their phlogiston be in a very combustible state, it nevertheless adheres to them in a very fixed manner, since they can support the most violent fire in close vessels without the least alteration, or loss of any part of their inflammable principle.

This principle, however, is not so adherent to the earth of coals, that it cannot quit it to combine with other substances, with which it has a stronger affinity; for instance, with the vitriolic, nitrous and phosphoric acids, and with metallic earths. Accordingly, coals by exposure to a violent fire in close vessels together with any of these substances, are decomposed, their phlogiston is separated and combined with the substance applied to it, with which it forms a new inflammable compound; common sulphur, for instance, with vitriolic acid; nitrous sulphur with nitrous acid; phosphorus with phosphoric acid; and, lastly, metals, with metallic earths: coal is therefore one of the fittest inflammable substances for transmitting phlogiston to other matters, and therefore is much employed for that purpose in chemical operations. See COAL.

The properties of phlogiston are particularly evident and distinct in metallic matters. The decomposition and recombination of all imperfect metals and semimetals, by the subtraction and restitution of the inflammable principle, leaves no doubt that this principle is one of their essential constituent parts. This is a chemical truth, which may be considered as demonstrated.

We may separate phlogiston from metallic matters by the general method by which it may be separated from all combustible bodies, that is, by combustion in open air; for without this condition, the phlogiston of metals, even the most combustible, is no more capable of burning in close vessels than that of coals. See CALCINATION, CALX (METALLIC), and COMBUSTION.

All mineral acids, and even the combined action of water and of air, are capable of depriving metals of their phlogiston, which is then done without any combustion.

Metals calcined, reduced to calxes or earths by some of these methods, or rather metallic earths, are capable of combining again with phlogiston, and of resuming all the metallic properties by several methods; that is, by fusion with coal, or other inflammable matters which are converted into coal during the operation. This is the ordinary method of reducing or recomposing metals. See REDUCTION. Metallic earths may also recover their phlogiston, by applying this principle in the state of vapors, or even by the humid way, by treating them with liver of sulphur, oils, &c. But the phlogiston of metals seems to be nevertheless in a dry state, as well as the phlogiston of sulphurs and of coals, as all the properties of metals shew. Thus if their earths are capable of recombining with the inflammable principle, even by the humid way in certain circumstances, the humid combination of phlogiston must be itself decomposed on these occasions, and this principle must be separated from all moisture to combine, at least in an intimate manner, with metallic calxes, and to reduce them into true metals. This reduction is similar to the production of sulphur in the humid way. See REDUCTION and SULPHUR.

As the calcination and reduction of metals are performed by the separation and restitution of the inflammable principle alone, we may, by comparing the properties of metals with those of their calxes, obtain demonstrative proofs of many of the essential properties of phlogiston, which we have mentioned in the beginning of this article.

Metallic calxes are generally harder, more solid, more fixed, less dense, less fusible, less opaque than the metals. All these qualities then, more or less eminent in metals, proceed from phlogiston. Further, the earths of metals,  
by



by losing their phlogiston, lose also their solubility in acids : hence phlogiston is an intermediate substance by which metals are dissolved in acids, from the great affinity which it has with these solvents. We shall now mention some particular instances of what we have here advanced in general.

Lead and tin are very soft metals ; nevertheless, when lead is calcined and afterwards melted, a glass is formed much harder than the lead from which it was produced. Tin, which calcines still more completely than lead, is easily changeable into a white earth, the parts of which, though very fine, are so hard, that they are employed to polish very hard bodies, as steel, glass, &c.

The most volatile semimetals, as regulus of antimony and zinc, are changed by burning their phlogiston into perfectly fixed earths.

Regulus of antimony and tin are fusible with a gentle heat ; yet the calxes of these metals are justly considered amongst the most refractory bodies.

The density, opacity, and ductility which metals receive from their phlogiston evidently proceed from the particular manner in which the parts of the phlogiston are applied to those of the metallic earths. These properties seem to shew that the primary integrant parts of phlogiston, although perhaps the smallest of all imaginable atoms, are essentially very dense and very opaque ; and also, that to give these qualities so eminently to metals, they must be capable of filling very accurately the small interstices betwixt the primary integrant parts of the metallic earths. The last mentioned properties of phlogiston seem to favour the opinion of Beccher and Stahl, who consider it as an earthy substance, the parts of which are exceedingly small, not, or but little, coherent to each other, and fitter than any other substance to acquire the rapid motion in which consist all the effects of fire ; or rather, it is the only substance capable of receiving the igneous motion. *See METALS and METALLISATION.*

Although phlogiston shews, in all chemical experiments, a strong repugnancy against uniting with water, and even with any substances containing water, we, nevertheless, find it combined with this principle in oils, resins, and in all vegetable and animal inflammable substances. We cannot doubt that these matters contain water ; for it is obtained in their analysis, and also their inflammability sufficiently proves that phlogiston is one of their constituent parts. Hence we find, that these two substances may assist in the composition of one body : but probably they are not united together immediately in oily compounds, but by means of an earth or rather of an acid ; for we know that phlogiston unites much more readily with earths and acids than with water ; and also, that earths and acids are obtained in the analysis of all oily substances.

As then oils are much more compounded than sulphurs, metals, and coals, the phenomena exhibited by phlogiston in oily matters are different from those in these other inflammable bodies. Phlogiston adheres less to oily matters, and is more readily combustible, and also when it is disengaged by inflammation it is always accompanied with some of the other principles of the oily matter which it carries along with it, that is, of the water, acid, and earth which compose this matter ; all which together form an oily flame. In this combustion even all the phlogiston is not dissipated : one part of it attaches itself much more intimately with the earth of the oil, and forms with this earth a matter black,

very

very fixed, and much less combustible than oil, called *lamp-black* or *foot*. It is a kind of coal, and is considered by Stahl as almost pure phlogiston.

This fuliginous quality by which oils differ from other inflammable matters, is in a greater or less degree, according to the nature of oils, and the greater or less activity with which they burn; in general, the more quickly and strongly they burn, the less fuliginous matter is formed; so that perhaps if an oil was reduced altogether to vapors, it might be burnt in an instant without forming any fuliginous matter.

When oils are decomposed without combustion, and by distillation, something similar happens. The phlogiston of the decomposed part of the oil attaches itself to the fixed and earthy part of the oil, intimately unites with it, and forms a coal. In this manner are all coals made.

Oil can transmit phlogiston to all the substances capable of uniting with it; but in the formation of intimate combinations, as those of sulphur and metals, the water must necessarily be separated from the oil. The same also is observable of foot and coal, although these substances have been produced from oil itself; yet their phlogiston is never in a state of perfect combination, unless they be quite dry. See OILS and COAL.

*Ardent spirit* and the *spiritus rector* of vegetable and animal substances are also compounds in which are contained both phlogiston and water; for these substances are, at the same time, very inflammable and miscible with water. Besides, water is obtained in their decomposition. The phlogiston of these substances is, nevertheless, in a very different state from that of oils; for their flame is less luminous, and is not accompanied with any foot. The cause of this difference probably is, that phlogiston is more immediately united with water in these spirits than in oils. Some chemists even imagine, that in ardent spirits phlogiston is united to water without any intermediate substance. The acid is certainly in less quantity and less sensible in spirituous inflammable liquors than in oils properly so called; and also these spirits may be approximated to the nature of oils, or even changed into true oils, by treating them with acids. See OILS. SPIRIT (ARDENT), SPIRITUS RECTOR, and ETHER.

From these properties of phlogiston it appears, that it is a principle dry, volatile, susceptible of the igneous motion, capable of combining with primary principles, as earth and water, but much more difficultly with this latter; that it is a component part of many bodies, to which it communicates an inflammable quality; that it is capable of passing from one combination to another; and that it is identical, or the same in all compounds, as the other principles are. Stahl thinks, that phlogiston is not elastic; and indeed most inflammable vapors, in which this principle seems to be almost pure, are not elastic: on the contrary, they destroy the elasticity of the air.

Hitherto the inflammable principle has never been obtained pure and single; and if it be nothing else than the matter of elementary fire, we evidently can never obtain it otherwise than as we have done; that is, in active and burning fire, by collecting the solar rays, &c. Nevertheless, in many occasions phlogiston discovers itself without inflammation, if not absolutely pure and simple, at least considerably so. Stahl believes, as we have already said, that foot is almost pure phlogiston. This matter does indeed seem to be one of the simplest combustible matters: but its great fixity and small degree of combustibility

buſſibility prove that in this ſubſtance the phlogiſton is intimately united with a conſiderable quantity of very fixed earthy matter, which is capable of diſguiſing many of its eſſential properties. I believe therefore, that we may conſider the very volatile, not inflamed vapors riſing from ſeveral combuſtible bodies on certain occaſions, as phlogiſton ſtill more ſimple, more copious, and more diſengaged. Such, for inſtance, are the vapors of ſulphur formed into liver of ſulphur, particularly when it is precipitated by an acid, or expoſed when dry to a gentle heat, incapable of kindling ſulphur: ſuch alſo are the vapors of coals of all kinds when they burn weakly and ſlowly, becauſe then a conſiderable quantity of the inflammable principle of theſe coals is exhauſted without being inflamed. The ſubtile vapors diſengaged from matters undergoing the ſpirituous and putrid fermentations, the vapors of mines and ſubterranean places, called *damps*, appear alſo to be of the ſame kind. All theſe vapors are ſimilar in this reſpect, that when they are not at liberty to diſſipate themſelves in open air, they have the property of abſorbing air, or of deſtroying its elaſticity, and of acting ſuddenly upon the brain and nervous ſyſtem of men and animals, whom they affect with drunkenneſs, ſtupor, ſtupor, ſtupor, ſyncope, and death. Theſe exhalations are, all ſuſceptible of being inſtantly inflamed, and with more or leſs exploſion, according to circumſtances, when they are accumulated and confined in a place, and a lighted ſubſtance applied to them. Theſe vapors then are conſiderably analogous. They all proceed from bodies abounding in inflammable principles, and are themſelves inflammable: laſtly, when they are applied to any body capable of combining eaſily with phlogiſton, ſuch as, for inſtance, metallic calxes not much dephlogiſticated, they very quickly and eaſily adhere to it. We ſeem then to have reaſon to preſume, after all theſe facts, that theſe emanations are nothing but the inflammable principle, almoſt pure, and which is but weakly connected with ſome other principle.

Such are the chief properties of this principle, the knowledge of which has become ſo important and eſſential ſince the diſcoveries of Beecher, Stahl, Geoffroy, and other modern chemiſts.

**LXXXVII. PHOSPHORUS (ENGLISH), or KUNCKEL'S PHOSPHORUS.** The name *phosphorus* is applied to all ſubſtances capable of giving light in the dark; ſuch as glow-worms, rotten-wood, diamonds after having been expoſed to the ſun or light, the Bolognian ſtone, and certain ſpars after calcination. The effects of theſe phoſphoric matters proceed from electricity, or ſome property of light. We ſhall mention theſe in the following article. The phosphorus we now treat of is of a very different nature. It is a ſubſtance not only luminous in the dark, but alſo inflammable and burning. It is a combination of phlogiſton with a peculiar acid, and is conſequently a ſpecies of ſulphur.

The diſcovery of this phosphorus is not very ancient: it was diſcovered by a citizen of Hambourg, called Brandt, in his reſearches for the philoſopher's ſtone. Kunckel was deſirous to acquire this ſecret, and for this purpoſe associated himſelf with one of his friends, called *Kraaft*, who thinking by means of it to make a fortune, reſolved, after having procured it, not to reveal it, and even obtained a promiſe from the inventor not to communicate it to Kunckel.

Kunckel,

Kunckel, vexed by this treachery, resolved to search for the phosphorus : and although he knew no more of the process than that urine was the substance employed, he prosecuted this inquiry with such zeal, that at length he made phosphorus. This chemist took to himself very justly the honor of having discovered it, and was accordingly considered as one of the discoverers of it, with so much more reason, as he did not find it by chance, and without searching for it, as Brandt had done, but after a rational inquiry undertaken for this purpose. Accordingly Kunckel's name is affixed to this phosphorus, which is commonly called the *phosphorus of Kunckel*.

The celebrated Mr. Boyle has also had the reputation of having made this discovery. Those who give him the credit of this say, that Boyle having seen a bit of phosphorus in England in 1679, which Kraaft had brought thither to shew to the King and Queen of England, and having been informed only that this phosphorus was produced from some matter belonging to the human body, attempted, like Kunckel, to discover the method of preparing it, and in the following year actually made a small quantity, which he lodged with the secretary of the Royal Society, who gave him a receipt for it. But Stahl, in a small work called the *three hundred experiments*, says that Kraaft told him that he communicated the process to Mr. Boyle. If this be true, Boyle has claimed the honor of a discovery to which he had no right, an imputation injurious to the reputation of a man so justly famous. But we must acknowledge, that the truth of this imputation is very questionable. For Kraaft, who, as Stahl relates, was ignorant of chemistry, who had been treacherous to Kunckel, was nothing in all this affair of phosphorus, but a trader in secrets. For having purchased the secret of preparing phosphorus, he sold it again every where, and therefore no credit is to be given to the testimony of such a man. However that may be, Boyle communicated the process for making phosphorus to a German chemist called Godfreid Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only persons who made any considerable quantity of it, and the latter made a lucrative trade of it. Stahl says, that he knew also this Mr. Hantkwitz, and considered him as a good practical chemist, and that he had an excellent laboratory in London.

Processes for making phosphorus were frequently published about that time. Mr. Hellot, in his Memoir upon this subject, enumerates all that were then known, namely, the process published by Boyle in 1680, in the Philosophical Transactions, No. 196; that of Kraaft; for, after selling the secret to many persons, he afterwards published it, in a treatise concerning phosphorus written by the Abbé de Commieres, published in the *Mercure Galant* for June 1683; that of Brandt, in a Collection of Experiments and Observations of Dr. Hook, published by Mr. Derham in 1726; that of Mr. Homberg, in the *Ancient Memoirs of the Academy* in 1692, who says that he had seen Kunckel make phosphorus; and, lastly, the processes found in the works of several chemists, particularly of Leickmeyer, Hoffman, and Neewentuit.

But notwithstanding all these processes, whether they were not sufficiently complete, or too laborious and expensive, no chemist, excepting Hantkwitz, made phosphorus, and the operation still continued a secret till the year 1737, when a stranger came into France, who offered to make phosphorus. The ministry granted him a reward for his process, which he accordingly communicated.

municated. Messrs. Hellot, Dufay, Geoffroy, and Duhamel, all experimental philosophers and chemists of the Academy of Sciences, executed this process successfully. Mr. Hellot wrote a distinct account of it, and published it amongst the Memoirs of the Academy of Sciences for the year 1737; a large extract of which may be found in the Elements of Practical Chemistry.

Since the publication of the memoir of Mr. Hellot, the process of phosphorus has been no longer a secret. But as this operation has hitherto been rather curious than useful, and is also expensive and troublesome, I do not know that any French chemist repeated it at that time, excepting Mr. Rouelle, who soon afterwards began a course of chemistry, in which he undertook to make phosphorus in presence of his pupils. I was then present as one of these, and Mr. Hellot attended during the whole operation. We continued there the whole night; but from a fault in the retort, this first operation failed. However, in the years following Mr. Rouelle succeeded many times.

Lastly, in 1743, that intelligent chemist Mr. Margraaf, who had several years been employed in making experiments upon phosphorus, published in the Memoirs of the Academy at Berlin a new and excellent process for obtaining more easily and expeditiously, and at less expence than has been done hitherto, a considerable quantity of phosphorus. This process is repeated successfully every year by Mr. Beaumé in the courses of chemistry which he gives with Mr. Macquer.

To make phosphorus by Mr. Margraaf's process, a kind of plumbum corneum is previously prepared, by distilling a mixture of four pounds of minium with two pounds of powdered sal ammoniac, from which all the volatile alkali, which is very penetrating, is by this operation obtained. The residuum after the distillation, that is, the plumbum corneum, is to be mixed with nine or ten pounds of extract of urine boiled to the consistence of honey. Mr. Margraaf requires that this urine should be putrified, which is unnecessary, according to Mr. Beaumé's observation. This mixture is to be made slowly in an iron caldron set upon the fire, and by frequently stirring, the matters. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder. This powder is to be put into a retort; to extract from it, by a moderate and graduated heat, all the volatile products of urine, that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this distillation the heat is to be only raised so as to make the matter red-hot. After the distillation a black and friable residuum remains, from which the phosphorus is to be extracted by a second distillation, and a stronger heat. Before it is exposed to another distillation, it may be tried by throwing some of it upon hot coals. If the matter has been well prepared, a smell of garlic exhales from it, and a blue phosphorical flame is seen, undulating along the surface of the hot coals.

This matter is to be put into a good earthen retort capable of sustaining a violent fire. Mr. Margraaf recommends retorts of *Waldenbourg*, or those which are made near *Kirchen* in Saxony; which not being known in France, we use Hessian retorts, although they have the inconvenience of allowing a large quantity of phosphorus to transpire during the operation. Mr. Beaumé secures his retorts with a covering of clay and hair.

Three quarters of the retort are to be filled with the matter which is to yield the phosphorus. It is to be placed in the common furnace for distillation with a retort; excepting that instead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to six inches, according to the size of the furnace, and the height from eight to nine feet. This apparatus, which Mr. Beaumé uses, is necessary for raising a sufficient heat, and for the conveniency of throwing in a sufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate size, pierced with a small hole, and half full of water. For this purpose ordinary fat lute may be bound on with strips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort passes ought to be well stopped with furnace earth. Lastly, a small wall of bricks is raised betwixt the furnace and receiver, to guard this vessel against heat as much as is possible.

All these preparations being made the evening before the distillation is to be performed, we are then capable of proceeding to this operation, which is very easy. The retort is to be heated by slow degrees during an hour and a half; and then the heat is to be increased till the retort be red-hot, and the phosphorus begin to pass in luminous vapors: when the retort is almost of a white red heat, the phosphorus passes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more passes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Mr. Margraaf's apparatus is somewhat different from that above described. He divides the whole quantity of matter from which the phosphorus is to be obtained into six small retorts, which he places in a furnace that he describes. The advantage of this division is, that if any accident happens to one retort, the whole matter is not lost; and as the retorts are smaller, a less heat is required. If indeed much phosphorus was to be made, this practice would be safe and excellent; but I can affirm, that the method above described of Mr. Beaumé is very convenient when a large quantity of phosphorus is not wanted, and that I have never seen it fail.

Phosphorus does not pass pure in this distillation, but is blackened by soot or coal, which it carries along with it: It may be easily purified and rendered white and fine by a second distillation or rectification. This rectification is made in a small glass retort, to which is adjusted a small receiver half full of water. A very gentle heat is sufficient, because phosphorus once formed is very volatile: and as the fuliginous matters with which it is soiled were raised merely by the violence of the heat, they remain at the bottom of the retort in this distillation; and the phosphorus passes very pure.

The phosphorus is then usually divided into small cylindrical rolls, for the conveniency of using it. This is done by putting it in glass tubes immersed in warm water. This very gentle heat is sufficient to liquify the phosphorus, which is almost as fusible as tallow. It takes the form of the glass tubes, from which it may be taken out when it is cold and hardened. That it may be more easily taken out of the tubes, these must be somewhat of the form of frustums of

of cones. All these operations ought to be made under water, to prevent the inflammation of the phosphorus.

The process published by Mr. Hellot for the preparation of phosphorus is only different from this in two respects; first, that his is only one operation, and not divided into two, as Mr. Margraaf's is; and, secondly, that he does not use plumbum corneum. The operation is certainly much facilitated by Mr. Margraaf's method of separating the volatile matters of the urine by a previous distillation; because after that, nothing more is requisite but to apply heat sufficient to raise the phosphorus; which may be done in four or five hours; whereas without this previous operation, the distillation lasts twenty-four hours. We are not so certain concerning the advantage of adding plumbum corneum, or whether it might not be omitted; for, as this addition does not much encrease the trouble of the operation, chemists who have hitherto made phosphorus by Mr. Margraaf's process have followed it in every point, without making any experiments to determine the necessity of this addition.

Phosphorus is a kind of sulphur composed of a peculiar acid united with phlogiston. This matter is extremely fusible, as we have seen. It has, like sulphur, two kinds of inflammation; one very weak, emitting a flame not powerful enough to kindle other combustible matters, but sufficient for the gradual consumption and burning of its own phlogiston; the other is vivid, brilliant, and strong, accompanied with decrepitation, and capable of kindling instantly any combustible matter. These two flames of phosphorus are easily distinguishable during the distillation of it, when the small hole of the receiver is unstopped; for when the vessels are not too much heated, the flame which issues through the hole is luminous in the dark, but does not kindle any combustible matter; it may be touched without danger, and it only renders the hands that touch it luminous. But when the vessels are too much heated, the flame issues with more force; it then decrepitates, and is capable of burning any person that touches it. This flame is a sign that the heat is too strong, and therefore when it is perceived, the fire ought to be lessened.

Phosphorus resembles vitriolic sulphur also in this point, that all its phlogiston may be burnt, even with rapidity, without any decomposition of its acid.

But it differs from sulphur in being much more combustible. In this circumstance it seems to be in a middle state betwixt the vitriolic and nitrous sulphurs. A heat from twelve to fifteen degrees is sufficient to decompose phosphorus, and to make its phlogiston burn, weakly and slowly indeed, but with a sensible light, particularly in open air. To prevent this decomposition, it must be preserved under water; and even in water it is partly decomposed, and it fills the containing bottle with luminous vapors; its surface loses its semi-transparency, and becomes farinaceous; and the water becomes more and more acid.

When phosphorus is heated by fire, or by friction, it then violently inflames, burns fiercely, and emits many vapors, as sulphur does; which however differ from those of sulphur in smell, which is like that of garlic or arsenic; and also in being always visible, as a white smoke during day, and as a light, when in the dark.

Phosphorus does not seem to be so strongly disposed as sulphur is to unite with metals. Mr. Margraaf has tried to make this combination with all metals

and semi-metals. For which purpose he took some filings of each metallic substance, digested it with two parts of phosphorus, and distilled the mixtures. In all these experiments part of the phosphorus passed into the receiver, as when it is rectified; the other part was burnt, and the metals remained untouched, excepting copper and zinc, which were acted upon in the following manners.

Copper treated by Mr. Margraaf with phosphorus lost its metallic brilliancy, and became more compact; a gros or 72 grains of copper being twice treated in this manner with phosphorus, was found to have acquired ten grains in weight, and to be rendered capable of being kindled when exposed to flame.

Zinc treated twice with phosphorus in the same manner, and exposed to strong heat at the end of the second distillation, was sublimed almost entirely in form of light pointed flowers of a reddish-yellow color, which being put under a muffle, were inflamed and vitrified, forming a transparent glass like that of borax. From these experiments we see that phosphorus has little disposition to unite with metals, which property perhaps proceeds from the facility with which it is decomposed.

According to the experiments of the same Mr. Margraaf, phosphorus sublimes with arsenic into a compound of a shining red color, in which respect it resembles common sulphur. It easily unites with sulphur. Equal parts of these two matters being mixed together and distilled, passed into the water of the receiver, congealed there, forming a substance which when rubbed by the fingers, could not easily be inflamed, but gave a yellow light, and readily kindled when exposed to a heat nearly equal to that of boiling water. Mr. Margraaf says, that this compound had a foetid smell, like that of liver of sulphur; and that it swelled in water, to which it gave a sulphureous smell, and manifest acidity; which effects prove a decomposition of these substances.

Mr. Margraaf treated phosphorus also with the three mineral acids by distilling them together in a retort; and these experiments furnished very curious observations. Vitriolic acid decomposed almost entirely phosphorus, but without any inflammation. Nitrous acid attacked it with violence, even without the help of fire, and occasioned a sudden inflammation, with explosion and rupture of the vessels. Lastly, marine acid produced no alteration upon phosphorus, nor was itself altered. These phenomena are perfectly analogous to the affinities of the three mineral acids with the inflammable principle.

Phosphorus is soluble in oils and inflammable liquors, nearly as sulphur is, and consequently forms *balsams of phosphorus*. But when combined with these substances, it seems to be more disposed to decompose, than when it is alone; for these oily phosphoric liquors are always luminous, particularly when they are heated a little, and are exposed to air.

But phosphorus differs essentially from sulphur by the nature of its acid, which is not yet well known by chemists. They believed a long time that it was the same as marine acid. Stahl was of this opinion, and others received it. That great chemist, in other respects so accurate and so much to be credited, was induced to this opinion by considering that urine contains much common salt, and that common salt exposed to contact of burning fuel is reduced to flowers, makes the coals burn more intensely, and occasions a flame similar to that of phosphorus. We have reason to wonder that such a chemist



as Stahl should pronounce concerning the nature of this acid from so slight reasons, when we consider that the properties of the phosphoric are so very different from those of the marine acid. But we shall be more surprised to find that he positively affirms, in his book called *Three Hundred Experiments*, that to make phosphorus, nothing more is requisite, but to mix and combine properly marine acid with phlogiston; and that by prosecuting what he had published concerning the artificial composition of sulphur, we may make phosphorus as abundantly and easily as sulphur itself.

We cannot wonder that chemists, trusting to so great an authority, should have firmly believed that the acid of phosphorus was the same as marine acid. Accordingly when Mr. Margraaf undertook to simplify and improve the process for phosphorus, he made many experiments to combine marine acid directly with phlogiston. We see in his memoirs, that he made these trials not only by employing common salt, but also several combinations of its acid with other bases. He employed *sal ammoniac*, *corneus metal*, and *marine salt* with earthy bases. He also varied the matters which were to furnish the inflammable principle; instead of urine he employed several vegetable coats, and even other animal matters, such as the oil of hartshorn, human blood, &c. But all these experiments were unsuccessful, or yielded but a very small quantity of phosphorus. He found the necessity of returning to the use of the extract of urine: and Mr. Margraaf having tried to distil it alone, and being assured by comparative experiments that this extract produced as much phosphorus when he distilled it alone as when he mixed it with matters capable of furnishing marine acid, as, for instance, luna cornea, this able chemist then suspected that the phosphoric acid was different from that of common salt.

On the other side, as urine contains, besides common salt, a considerable quantity of a singular kind of salt, which chemists call *fusible salt*, or *native salt of urine* (See URINE), Mr. Margraaf, who found that he could not obtain phosphorus from common salt, nor from any of the combinations of its acid with other bases, was naturally led to suspect that this native salt of urine contained the true phosphoric acid. This he afterwards ascertained by many demonstrative experiments. Having distilled this salt only with inflammable matters, he easily obtained a very large quantity of phosphorus; and also having distilled an extract of urine, from which he had separated all the fusible salt, and having by this method obtained scarcely any phosphorus; and, lastly, having examined and compared the properties of the phosphoric acid with those of the acid of the fusible salt, and having found them entirely the same, he acquired on this subject all the certainty which is possible. We shall see from the enumeration of the properties of phosphoric acid, how much it differs from the marine, and all other acids. To Mr. Margraaf also we owe the knowledge we have concerning this important subject.

When the inflammable principle of phosphorus burns, and separates from the acid by this combustion, the acid remains disengaged, as the acid of sulphur does, by the combustion of sulphur. We obtain then, after the combustion of phosphorus a substance at first dry, but which quickly and powerfully attracts the moisture of air, because the acid is so concentrated as to be dry. This matter is soon reduced to a very acid liquor, of the consistence of very concentrated vitriolic acid. It has an acid taste; it converts the blue color of vegetables to a red, and combines to the point of saturation with

alkaline

alkaline substances. Thus its acid quality is not doubtful. The fixity of this salt is very singular. It not only may be deprived by heat of all the moisture by which it is kept liquid, but also when thus dried it may be rendered red-hot without sublimation, and may be thereby changed into a solid and transparent matter, which has all the appearance of glass. Mr. Margraaf observed that phosphoric acid, thus dried and heated, emitted a smell of garlic, and also some luminous sparks; which proves that phosphorus does not lose by combustion all its phlogiston, but that a portion of it still remains united with the acid, and which seems to have been protected from combustion by this acid.

Phosphoric acid appears to be a very powerful solvent. It easily decomposes nitre and common salt, from which it disengages the acids and unites with the alkaline bases, as vitriolic acid does. According to Mr. Margraaf's experiment, it also decomposed vitriolated tartar. These remarkable properties ought probably to be attributed to its great fixity.

When it is combined to the point of saturation with alkaline salts, it forms neutral salts entirely similar to the fusible salt of urine.

Mr. Margraaf has also examined the action of the phosphoric acid upon metals. From these experiments we find that this acid does not dissolve gold, not even when mixed with the nitrous acid; which proves that it is very different from marine acid. It does not attack silver. It acted a little upon filings of copper, which rendered it green, but it easily dissolved the calx of copper. Iron is entirely and easily soluble in this acid, and forms with it a crystallizable metallic salt. Tin is only weakly corroded by this acid, which must be well concentrated to produce even this corrosion. It has nearly the same effect upon lead. The color only of mercury, precipitated *per se*, is changed from a red to a yellow and a white, and by a long digestion to a black. It entirely dissolves white arsenic. Lastly, it dissolves perfectly zinc, from the solution of which a fetid smell arises. This acid when treated by fusion with metallic substances exhibits nearly the same phenomena, only with greater force; and with those metallic matters which contain much disengaged phlogiston, as tin, lead, and especially iron and zinc, it forms phosphorus. Mr. Margraaf obtained a large quantity of excellent phosphorus by distilling, with strong heat, zinc and phosphoric acid.

We shall now shew what effects are produced by this acid, when added to solutions of metals by other acids. At first it produces no change upon the solution of gold in aqua regia; but some time afterwards it precipitates part of the gold in its metallic state. It affects the solution of silver nearly in the same manner, only that the quantity of silver thus precipitated, which resembles silver precipitated by copper, is so small, that it cannot be estimated. Mr. Margraaf adds, that by distilling to dryness this mixture of solution of silver with phosphoric acid, a matter remained which did not differ from a *transparent luna cornea*. Nevertheless it was found to be not a true luna cornea, but a mixture only of silver with phosphoric acid: for this matter, when placed upon a coal and heated with a blow-pipe, melted into a dark grey glass. From the solution of mercury in nitrous acid, a copious white precipitate is formed by means of phosphoric acid. But a singular circumstance is, that this precipitate is redissolved, when the mixture has remained some time exposed to the cold. Mr. Margraaf adds, that having distilled this mixture, he obtained a con-

a considerable quantity of a white and shining mass, which by the heat of a blow-pipe was vitrified into a very transparent glass. But this circumstance seemed very extraordinary, that after he had mixed the residuum with pure lead, and cupelled this mixture, he obtained a regulus of fine silver, the quantity of which was at the rate of six drams per quintal. A white precipitate was made from a solution of lead in nitrous acid by the phosphoric acid; but this precipitate was not redissolved.

These are the properties of phosphorus, and of the phosphoric acid; most of which were discovered and ascertained by Mr. Margraaf. They shew that this acid differs no less from the marine than from other acids, and that its nature is peculiar. Mr. Margraaf, probably from the respect he has to the opinion of Stahl, does not absolutely decide that it is different from the marine acid, but he says that it certainly is not pure and crude marine acid. He thinks, that possibly it may be marine acid very intimately combined with some subtle vitrescible earth. And indeed the fixity and vitrescibility which principally distinguish the phosphoric acid, seem to shew that it contains a larger quantity of such a principle than all other acids.

The phosphoric acid seems at the same time to partake of the nature of *sedative salt* and of *white arsenic*. Sedative salt, without having very distinct acid properties, acts as an acid on many occasions. It combines with alkalis, saturates them, and reduces them to neutral salts. It is fixed in the fire, in which it melts as a vitrescent matter, like the phosphoric acid; like which also it decomposes neutral salts. See BORAX and SALT (SEDATIVE).

Arsenic is not indeed fixed, as the phosphoric acid is; and it decomposes no other neutral salt than nitre: but it is disposed to vitrification, and has a smell entirely similar to that of the phosphoric acid.

Phosphoric acid is not found solely in animal urine. Mr. Margraaf found that many vegetable matters, particularly farinaceous grains, contain enough of this acid to produce phosphorus, when they are exposed to great heat in close vessels. This acid therefore is probably formed in the vegetable and animal kingdoms, and passes from the former into the latter: but the largest quantity of it is found in urine. See URINE and SALT (FUSIBLE) of URINE.

Hitherto phosphorus has not been employed for any useful purpose. But we may hope that some use might be found for it, particularly if it could be made in large quantities and cheap, for its dearness has certainly prevented the proper trials and researches for this purpose. Although it were only to remain an object of curiosity, it would still be amongst the first of that kind. Many amusing experiments may be made with phosphorus, which would be more surprising if it were less known. For instance, one may write upon a wall with a roll of phosphorus, and the writing will presently appear in letters of fire. The face, or any other object, may be covered over with phosphorus dissolved in oil, by which it is rendered luminous in a dark place, particularly if the air be heated a little. A taper may be extinguished, and instantly kindled by applying to the wick while yet hot the point of a knife, to which a piece of phosphorus has been fixed by means of suet. Finally, it is one of those substances, by which such magicians as Comus may perform operations which greatly surprise those who are not in the secret.

**DXXXVIII. PHOSPHORIC STONES.** These stones, when properly calcined, have the property of shining in the dark. The most celebrated and most anciently known phosphorus of this kind, is that called the *Bolognian stone*, from Bologna, a city of Italy, near which this stone is found. Lemery relates, that the person who first discovered the phosphoric property of this stone was a shoe-maker, called Vincenzo Casciarolo, who used to make chemical experiments. He says that this man, walking at the foot of Mount Paterno, gathered some of these stones, the great weight and lustre of which had induced him to believe that they contained silver; and that after having exposed them to fire, and carried them into a dark place, by accident probably, he perceived the stones shining like hot coals, which much surprized him, and induced him to repeat the experiment. From that time the Bolognian stone has been operated upon by chemists and experimental philosophers, who have searched for the most advantageous method of calcining it to render it luminous.

For this purpose we find different processes in the works of La Poterie, of Montalban, of Mentzel, of Lemery, and in the Memoirs of Homberg and du Fay, printed amongst those of the Academy. But nobody has treated this matter so fully, or illustrated it so well, as the celebrated Mr. Margraaf in two Dissertations upon this subject. Wherefore, without attending to what has been said before him, we shall relate here summarily his opinion concerning the nature of Bolognian stones, his method of preparing them, the phenomena they exhibit, and the matters analogous to them; so that the whole of this article shall be extracted from the Dissertations of that able chemist.

Bolognian stone is soft, friable, heavy, crystallized, and incapable of effervescing with acids before it has been calcined in contact with fuel. These qualities have induced Mr. Margraaf to class it amongst the heavy fusible spars, and with so much more justness, as all these spars by a preparation similar to that for the Bolognian stone are rendered phosphoric. As these spars are also composed of the same principles, as we shall afterwards see, all that we shall say concerning the Bolognian stone is also applicable to all other stones of the same kind; that is, to all the heavy fusible spars, or rather to the *selenitic* spars.

When these stones are to be rendered phosphoric, such of them ought to be chosen as are the cleanest, best crystallized, most friable, most heavy, which exfoliate when broken, and, lastly, which contain no heterogeneous parts. They are to be made red-hot in a crucible, and reduced to a very fine powder in a glass mortar, or upon a porphyry. Lemery affirms, that this pulverization ought to be made in a brass mortar, and positively declares, that after many experiments, he found that the operation entirely failed, if any other, particularly an iron mortar, has been used. But Mr. Margraaf, whom we preferably follow, forbids expressly the use of a copper mortar, and affirms that it hurts the success of the operation. The stones having been thus reduced to powder, are to be formed into a paste with gum tragacanth, and divided into cakes as thin as a knife. These are to be dried by a heat, which at last is to be made pretty considerable. After these preparations, an ordinary reverberatory furnace is to be filled to three quarters of its height with charcoal, and the fire is to be kindled. Upon this charcoal the flat surfaces of the cakes are to

to rest; and more charcoal is to be placed above them, so as to fill the furnace. The furnace is then to be covered with its dome, the tube of which is to remain open; all the coal is to be consumed, and the furnace is to be left to cool. The cakes are then calcined, and are to be cleaned from the ashes by blowing with bellows upon them. When they have been exposed during some minutes to light, and afterwards carried into a dark place, they will seem to

if the stones be exposed to a stronger calcination during a full half-hour under a muffle, their phosphoric quality will be rendered stronger.

The phenomena exhibited by these stones rendered phosphoric by calcination are very worthy of attention, but are not well understood. The difficulty attending this subject, is increased by the contradictory relations of those who have operated upon this matter, in some important facts. Mr. du Fay, who has published a Memoir concerning this kind of phosphorus in the year 1730, asserts, from experiments, that all calcareous stones, whether they contain, or not, vitriolic acid, are capable of becoming luminous by calcination; with this difference only, that the pure calcareous stones require a stronger or more frequently repeated calcination, whereas those which contain an acid, as felenites, gypsums, spars, become phosphoric by a slighter calcination. Mr. Margraaf, on the contrary, who does not seem to have known this Memoir of Mr. du Fay, says, that no other stones can be rendered phosphoric but those calcareous stones only which are saturated with an acid; that purely calcareous stones, as marble, chalk, limestone, stalactites, are incapable of receiving this phosphoric quality, till they have been previously to their calcination saturated with an acid. The cause of this phosphoric property cannot be assigned till these facts are ascertained: for if all calcareous stones are capable of being rendered luminous without the concurrence of an acid, we may then suspect that light is capable of adhering more to some bodies than to others, and that calcination gives to calcareous stones the property of retaining a larger quantity of light, and during a longer time, than other bodies can. We must nevertheless confess that this conjecture is very vague, and not much supported by facts.

But if these stones cannot be rendered luminous without the concurrence of an acid, as Mr. Margraaf thinks, and as experiments indicate, if even the acid does only contribute considerably to give them this property, as all experiments upon this matter, and even those of Mr. du Fay, seem to shew; we then have reason to believe, that acids have a considerable share in the production of this luminous property. Our conjectures upon this subject are as follow.

We know that acids in general, and particularly the vitriolic and nitrous, have a strong affinity with the inflammable principle; that when they are mixed with this principle, they form with it compounds possessed of the properties of sulphur, or of phosphorus. We are also certain, that sulphur, phosphorus, and probably other compounds of acid and phlogiston with which we are not acquainted, have each two methods of burn-

ing; the first vivid and strong, in which their phlogiston forms a very sensible flame, and produces not only light, but also so considerable a heat as to kindle combustible bodies; the other slow and weak, capable only of producing a light much less vivid, without any sensible heat, or with a heat too small to kindle combustible bodies. Such, for instance, is *gun powder*. See *SULPHUR, PHOSPHORUS, and POWDER (GUN)*.

This being established, may we not with probability believe, that the acid contained in stones rendered phosphoric by calcination combines with the phlogiston of the coals, forming with it a sulphureous compound; and that the phlogiston of this kind of sulphur or phosphorus adhering but weakly to the acid, or existing there perhaps only superabundantly, is very easily combustible; so that merely the action of the heat and light of the open air is sufficient to inflame it: not, however, so strongly as to produce heat and a total dissipation of the phlogiston, as when sulphur and phosphorus are burnt, but so slowly, and weakly, that but a very faint light, observable only in the dark, is produced. Such is the light of the Bolognian and of other phosphoric stones of the same kind.

Several phenomena of this phosphorus seem capable of confirming this conjecture. First, the Bolognian stone, the spars and gypsums which are rendered luminous by calcination, have, according to all those who have operated upon them, a smell of sulphur after their calcination, and preserve this smell while they have the phosphoric quality.

Secondly, the calcination of these stones must be made in contact with coals, otherwise they are not rendered luminous, as Mr. Margraaf has observed. But we are certain that this is one of the conditions necessary for the production of all sulphurs, and of phosphorus of all kinds: and as this calcination is also made with the concurrence of the air, and succeeds better in this manner than in close vessels, the sulphureous compound formed in this operation is probably in a state of inflammation and combustion during the calcination, which gradually diminishes as the stone cools, so as to be rendered insensible by means of the great quantity of incombustible stony matter with which the sulphureous compound is covered and surrounded on all sides: the combustion, however, does not so entirely cease, but that merely the action of light is capable of renewing and encreasing it, so as to render it sensible in the dark.

Thirdly, Mr. Margraaf has observed, that every phosphorus of that kind which requires to be exposed to light in order to make it shine in the dark, may, without any such exposure, during two or three days or more, be rendered very luminous merely by being heated; that is, by a substance, which is at the same time incapable of giving light. For instance, a plate of iron heated so last reddens even in the dark. This curious experiment shews very clearly, that the phosphoric light proceeds from a very weak and slow inflammation, which is so checked by cold, that no sensible light proceeds from it, even in the dark, but which may be encreased and renewed by a very weak heat. This matter might be further illustrated by observing the effects of exposing this phosphorus to a great degree of cold at the time of its being very luminous. We should probably find that its light would be gradually diminished, and at length extinguished by the cold.

Thus we have strong reasons to believe, that the light of all these phosphoric stones is nothing but a very slow and weak combustion or inflammation of a certain quantity of phlogiston which they contain.

Many facts may indeed be objected to this opinion. 1. If the light of this phosphorus was only the effect of a true inflammation, it could not take place without the free access of air; and it would be extinguished, like that of other inflamed substances, when phosphorus is immersed in water or any other liquid. But we are certain that these phosphoric stones have the same effects when they are kept in bottles hermetically closed, or even when immersed under water, as Mr. de Fay has shewn. 2. Mr. de Fay found by experiments, that stones purely calcareous, and containing no acid, are nevertheless rendered phosphoric by calcination. But no sulphureous or phosphoric compound can be formed in these stones. Their light therefore does not seem to depend on any inflammation.

To these objections we may answer, that although in general inflammable bodies cannot burn with access of air, this rule is not however free from exceptions, in the instances of sulphureous and phosphoric compounds, particularly concerning that kind of inflammation which is weak and incapable of kindling other combustible matters, which must be carefully distinguished from their rapid combustion, as we have already remarked. We are certain that this weak and slow inflammation of such bodies may subsist without access of air, or at least with much less air than is necessary for the other inflammation, and proportionable to its weakness. We cannot doubt that the light proceeding from the phosphorus of urine is an effect of a weak combustion of this phosphorus, as may be seen under the article PHOSPHORUS of KÖNIGSEIL. But this light is well known to appear in water, in oil, in the best closed glass vessels, to increase by heat and to diminish by cold, which also happens to the phosphoric stones. Besides, although these stones may shine as well as phosphorus in water and in vessels perfectly close, their light is still weaker than in open air, and is much more quickly extinguished in water or other liquors than in air, according to the experiments of Mr. du Fay. In this respect then they are entirely similar to the phosphorus of urine: perhaps even ordinary sulphur heated, and properly treated, might exhibit the same phenomena (b).

(b) I doubt whether a phosphorus could be made of sulphur without addition of quicklime or other substance, to which the vitriolic acid has a disposition to unite. For the principal cause of that slow combustion which produces phosphoric light seems to be that the union between the acid and the phlogiston of such phosphoric substances, is weakened by the presence of some earth to which the acid has also a disposition to unite, and that the phlogiston is thereby gradually disengaged, especially when this is combined with air, to which it is still more strongly disposed to unite, as we may perceive from the necessary consequence of this fluid to maintain ordinary combustion, which is

only a more rapid and copious disengagement of phlogiston from the burning substances. Accordingly, if we examine the several kinds of phosphorus, we shall find that each of them consists of an acid, an earth, and phlogiston. From Mr. Margraaf's experiments we find that the Hologian and other phosphoric stones contain a selenites, or a calcareous earth united with vitriolic acid, and that the phlogiston is given to them during calcination. The phosphorus of urine contains also an acid and phlogiston. But from the experiments of the same excellent chemist we find, that this acid is always united with a peculiar earth. The phosphorus of Homberg is a combination of marine



In the second place, (as to Mr. du Fay's assertion, that calcareous stones become phosphoric by calcination, we may observe, that as he did not examine chemically the stones he employed, and made no experiments to determine whether they contained any vitriolic acid or not, we cannot be certain that they did not contain any. For we know, that many of the stones which seem to be entirely calcareous, do however contain more or less of gypseous or selenitic substances. Of this kind, perhaps, the stones employed by Mr. du Fay might be. Besides, if we suppose that these stones contained no acid nor sulphur, perhaps they are capable of retaining some of the phlogiston of the coals in the calcination, and we may easily conceive that this phlogiston alone is capable of producing a phosphoric quality. Lastly, we are certain, even from Mr. du Fay's experiments, that pure calcareous stones become much less luminous by calcination than those which contain an acid, and are rendered phosphoric much more difficultly.

After all that we have said concerning phosphoric stones, we ought to understand them clearly. The *phosphorus of Baldwin* and the *phosphorus of Homberg* are exactly similar to those made with the Bolognian stone and phosphoric spars, from which they differ only in the kind of acid which they contain.

The *phosphorus of Baldwin* is a combination of chalk with nitrous acid; and the *phosphorus of Homberg* is a combination of quicklime with the acid of sal ammoniac. The former is therefore a nitre with calcareous basis, and the other a marine salt with calcareous basis. They acquire the phosphoric property by calcination, as well as the Bolognian stone and spars do, which are vitriolic salts with basis of calcareous earth. These two matters are not to be calcined in contact with fuel, but in crucibles. The phosphorus of Baldwin receives its phlogiston from the nitrous acid; chalk also contains some phlogiston. The phosphorus of Homberg receives its phlogiston from the sal ammoniac which is treated with quicklime.

As the nitrous and marine salts with earthy bases are deliquescent, they attract the moisture of the air after they have been dried, and even after they have lost some of their acid by calcination; for which reason they cannot be preserved but in vessels accurately closed, and their phosphoric quality lasts much shorter time than that of spars. The theory of these two kinds of phosphorus seems to be exactly the same as that of phosphoric stones. See SPAR.

DXXXIX. P I N C H B E C K. See BRASS and SIMMON.

DXL. P I T C H. (i)

rine acid with calcareous earth, which absorbs phlogiston from the burning fuel during its fusion. The phosphorus of Baldwin is a similar combination of nitrous acid with calcareous earth; and the pyrophorus of Homberg is a combination of vitriolic acid, earth of allum, and the phlogiston of some, or other inflammable substance.

(i) PITCH. When the wood of pines, firs, and other trees, from which turpentine is obtained, is exposed to fire in vessels which have openings only at their bottoms, as, for instance, in an inverted retort, the re-

sinous and other juices melt out by the heat, and at the same time acquire an empyreumatic smell and taste. This is tar, which being boiled, exhales much acid phlogon and essential oil, and becomes thick. It is then changed into pitch. Pitch and tar consist chiefly of the resinous, but contain also much of the stony, saline, and earthy matter of the wood. Hence they are not much disposed to unite with oils and fat, and hence too they are gradually corroded by air and moisture, when employed to preserve wood, and other substances: as ships, casks, shingles,



## DXLI. PITCH (MINERAL). (k)

DLXII. PLANTS. See KINGDOM (VEGETABLE).

DXLIII. PLASTER. See GYPSUM.

DXLIV. PLATINA. Platina is a perfect metal, analogous with the perfect metals, especially with gold, as many properties are common to both.

Although metals, from their great utility, have been always diligently searched for, yet this has remained undiscovered till lately, which is a very surprising circumstance, and which seems to prove that platina is not, like the other metals, scattered in different parts of the world, and in all climates. Platina is found in the golden mines of Spanish America, and chiefly in those of Santa Fé near Carthegena, and in the Bailliwick of Choco in Peru.

This metal was probably known to the workers of these mines long before it was brought into Europe: but as its color is not very fine, and as it is almost intractable, especially by fusion, without addition, they seem to have neglected it, considering it as some refractory mineral or marcasite: some of them, however, had attempted to melt it, and to make toys of it, as tobacco-boxes and other things of that kind; but this must certainly have been by alloying it with other metals, as we shall soon see the impossibility of their doing it otherwise.

Nevertheless, this metal continued to be so neglected, that it was entirely unknown in Europe till Don Antonio Ulloa, a Spanish mathematician, who accompanied the French academicians sent by the King of France to Peru to determine the figure of the earth by measuring a degree of the meridian, first mentioned it in the relation of his voyage, printed at Madrid in the year 1748: but he says little of it, and represents it as an intractable metallic stone, which impeded the extraction of gold from the ore when it was in a large quantity. This account was not very likely to excite the curiosity of chemists concerning a new perfect metal, and a matter so interesting and surprising as they afterwards found it to be.

But before that time, that is, in 1741, an English metallurgist, called *Wood*, who had brought from Jamaica some specimens of it, which he was informed had come from Carthegena, attended more to it, and made some good chemical trials

shingles, &c. To render them more durable, and less liable to be melted by the heat of the sun in summer, an anonymous author advises that tar should be mixed when boiling-hot with coal-dust, in such quantity as to render it thick; by which preparation, he says, tar is fixed, never runs, bends and hardens surprizingly from heat and moisture.

From two ounces of pitch, one ounce and half a scruple of resinous matter were extracted by spirits of wine. Half an ounce of empyreumatic oil separated during the digestion, and nearly half an ounce of earthy matter remained, from which water extracted nothing. The same quantity of the

same pitch, boiled first in water, yielded two drams and half a scruple of gummy extract.

Eight ounces of pitch distilled in an open fire yielded two ounces one dram and a half of an acid spirit, and two ounces five drams of a fetid oil, three ounces of a shining black coal remaining in the retort. *Neuman.*

(k) PITCH (MINERAL). This is a fetid, black, thick, and tenacious bitumen, differing from petroleum in having a thicker consistence and a darker color. Petroleum, exposed to evaporation, deposits a substance similar to mineral pitch. It is used for the same purposes for which pitch and tar are applicable.

of it. Since that time, several chemists, the chief of which are M. Scheffer, of the Swedish Academy, and Dr. Lewis, of the Royal Society of London, have very particularly examined this singular metal, and have published their experiments. Dr. Lewis has in some measure exhausted this matter, in four excellent memoirs communicated to the Royal Society. Platina was, nevertheless, little known in France till the year 1758, when Mr. Morin, zealous for the progress of science, collected, translated into French, and published an account of all that had hitherto been done upon platina, in a work entitled, *Platina, White Gold, an eighth Metal*.

This publication excited the curiosity of French chemists, to whom it was a new and interesting object; but the difficulty of obtaining a matter so dear prevented all of them from being able to satisfy their desire of examining it. Messrs. Macquer and Beaumé were the only persons who made experiments upon it, which they have published amongst the *Memoirs of the Academy* for the year 1751.

About the same time also, Mr. Margraaf examined platina, and published a dissertation concerning it.

These are the only chemists who have examined, at least, who have published their researches concerning this new metal. But although their number be small, yet their experiments are so numerous, made with such accuracy, and in general so consistent with each other, that by collecting and comparing them, we may acquire as certain and almost as extensive knowledge of platina as of the other metals that have been known from time immemorial. This article shall contain the most general and certain results of the experiments made by the above-mentioned chemists.

*Platina*, a Spanish word, is a diminutive of *plata*, which in that language signifies silver. It is therefore called by the Spaniards *little silver*. This name is improper, since it resembles silver only in being indestructible, and very imperfectly in its color. The name of *white gold*, given to it by some chemists, is more suitable, for we shall see that it resembles gold more than any one metal resembles any other; and hence we shall chiefly compare it to gold.

We do not certainly know the origin and natural history of platina. We can only assert, that all that we see in masses, or worked into forms, is not pure nor in its natural state; for we are certain that it is unfusible, without addition, by the most violent fire of our furnaces. All the platina that is found in the cabinets of curious persons consists of small angular grains, the corners of which are a little rounded. It is mixed with a considerable quantity of small black sand, as attractable by magnets as the best iron, but insoluble by acids, unfusible, and untractable. This sand is perfectly similar to that which is found at St. Quay in Brezgne. The grains of platina are also frequently interspersed with particles of spar and of quartz, and sometimes with spangles of gold. Messrs. Macquer and Beaumé found a pretty large spangle of gold in the platina examined by them. But these heterogeneous matters are quite foreign to platina, and are not combined with it; for it contains nothing extraneous excepting a little gold and mercury, which latter substance it probably receives during the operations for extracting gold from the ore by means of mercury. These matters may easily be separated from the platina without decomposing it, by washing and by magnets. Some chemists, who know

platina only by name, and deny that it is a peculiar metal, have therefore, with great impropriety, advanced, that Mr. Margraaf had decomposed it, and had obtained from it gold, iron, and arsenic. The contrary appears from Mr. Margraaf's Dissertation. Mr. Margraaf only separated the heterogeneous matters which were merely mixed with platina, as other chemists have done; but he is too good a chemist to pretend that he has decomposed it: on the contrary, he does not hesitate to call it a *perfect metal*, which name is also given to it by all who understand metals.

The color of the grains of platina is metallic, white, livid, not very brilliant, intermediate betwixt the white of silver and the grey of iron. At first view they resemble large filings of iron. They are smooth, and are nearly as hard as iron; they are somewhat ductile; so that some of them may be flattened upon an anvil, while others are bruised into small pieces.

The specific gravity of platina is very great, and nearly equal to that of gold. In water it loses only something betwixt an eighteenth and a nineteenth part of its weight.

The tenacity of the parts of this metal has not been determined, because it cannot be formed into a proper figure to make the experiment. But if this quality is proportionable to the ductility and hardness of metals, we may presume, that as platina is much harder than gold, its tenacity is also greater, if all the ductility of which it seems susceptible could be given to it by art.

Platina is, like pure gold and silver, free from all smell and taste. It is unalterable by the combined action of air and water, and is no more susceptible than the other perfect metals of acquiring rust. Like them also, it is indurcible by the most violent and long continued fire: but the property which peculiarly distinguishes this metal is its infusibility by the most intense heat.

As fusion is necessary for the application of metals to use, chemists have made their utmost efforts to melt platina. The most violent heat which could be raised in air-furnaces, or by the united action of several large bellows, has been applied repeatedly, and continued a long time without success. In all these trials the grains of platina remained unaltered in form and weight, and were only agglutinated to each other, nearly as sand is by exposure to violent heat, but so slightly, that by the smallest effort they were separable. Messrs. Macquer and Berzoni exposed platina during five days and five nights to the greatest heat of a glass-house furnace, which trial did only confirm the unfusibility and unalterability of platina by ordinary fires, as it was found to be only a little agglutinated, and its weight to be a little increased; which latter phenomenon has been also observed by Mr. Margraaf. Lastly, Messrs. Macquer and Berzoni, having exposed platina to the focus of a large burning-glass, melted a drachm of it in a minute. It first smoked, then emitted sparks, and those parts of it melted well which were exposed to the center of the focus. These chemists carefully examined the properties of this platina. According to their mention, the melted parts were distinguishable from the others by a brilliancy like that of silver, and by a rounded, shining, polished surface. They were easily flattened upon an anvil, and formed into very thin plates without cracking or splitting, so that these grains seemed to be much more malleable than platina in its natural state. These metals by repeated strokes of the hammer become hard and brittle, as all other metals do, particularly gold and silver;

silver; and by annealing, their malleability was restored, as it is also to other metals by the same means. After experiments so certain and well authenticated, we cannot doubt that platina is truly a metal, and even a third metal, as perfect in its kind as gold and silver are in theirs. This proposition will be further confirmed by the other properties of platina.

Platina resists as perfectly as gold the action of the vitriolic, marine, or nitrous acids; in a word, of any pure acid, in whatever manner applied. These acids, concentrated or diluted, may be boiled any length of time upon platina without dissolving an atom of it: but a mixture of nitrous and marine acids, aqua regia, the solvent of gold, is also the solvent of platina. Messrs. Macquer and Beaumé have observed, that an aqua regia composed of equal parts of the two acids dissolves most of this metal. But, however the aqua regia is made, more of it is required to dissolve platina than gold. These chemists employed a pound of aqua regia to dissolve an ounce of platina. All the acid of this quantity of aqua regia was not indeed employed to dissolve the platina, because much of it was dissipated in vapors during the operation, from the long time employed in the solution; and therefore if the operation had been performed in close vessels, and by distillation and cohobation, as Dr. Lewis did, a less quantity of aqua regia would have been sufficient: but this is a matter of small importance.

Aqua regia requires to be assisted by the heat of a sand-bath, and also a considerable time, to dissolve platina well. Although the color of this metal is white, its solution is very yellow, even deeper than that of gold. When a small quantity of platina only is dissolved in aqua regia, or when a saturated solution is much diluted, a beautiful yellow color is produced, undistinguishable from that of a solution of gold: but while the aqua regia becomes more and more saturated with platina, its color becomes more and more intense, and at last red; but this apparent redness evidently proceeds from nothing but the intensity of the yellow color; for this saturated solution is rendered yellow by dilution with water. In this circumstance it is similar to tincture of saffron.

The solution of platina in aqua regia is acid and corrosive, and from it a neutral crystallizable salt may be obtained. When the acids employed are concentrated, and when the solution is nearly saturated, a confused crystallization is formed at the bottom of the matrafs, which may be found to be a heap of very small, yellow, transparent crystals. These crystals of platina may be obtained much larger and more beautiful by evaporating the solution of platina with a very slow fire, and by cooling it very slowly. I found that the solution of platina tinged the skin and other animal matters with a blackish brown color, in certain circumstances (in which respect it resembles the solutions of gold, silver, and of mercury), and that ether mixed with this solution by agitation quickly separates from it, and becomes tinged with a fine yellow color, precisely as it does when it is treated in the same manner with a solution of gold. This experiment shews, that ether, and probably other stricated oily matters, take platina, as they do gold, from aqua regia; and hence we may perceive another instance of the conformity of these two metals. But as ether does not acquire nearly so intense a color as the solution of platina, we may infer that it only receives a small quantity of this metal. Besides, the platina soon separates spontaneously from the ether.

Platina may be precipitated from its solvent by fixed and volatile alkalis (1); and these precipitates are all of a yellow brick-color, when only so much alkali is employed as is necessary to saturate the acid of the solution; but are of a paler color when a superabundant quantity of alkali is employed, or when they are digested in alkali. These colors of precipitates of platina proceed from a large quantity of saline matters which precipitate along with them, and which strongly adhere to them, and not from any calcination of this metal, or loss of its phlogiston. The proof of this is, that if the crystals or precipitates of platina be exposed to strong heat, the saline matters which adhere to them are expelled, the color occasioned by them is lost, and the platina recovers without any addition its ordinary metallic state.

All the above-mentioned phenomena exhibited by platina treated with acids and alkalis are similar to those which gold exhibits in similar circumstances: but platina has also in this respect some peculiar properties by which it differs from gold. 1. The solution of platina acquires a deeper color than that of gold. 2. The precipitate of platina made by volatile alkali does not fulminate as that of gold does. 3. Tin does not produce from the solution of platina a purple precipitate, capable of tinging glass, as it does from a solution of gold.

Neither nitre, which quickly and effectually calcines all imperfect metals; nor corrosive sublimate, the acid of which, being very much concentrated, acts upon almost all metals; nor any other neutral salt, could occasion the smallest alteration upon platina or upon gold.

This singular metal resists, as well as gold does, the action of sulphur, which so powerfully dissolves other metals. From Dr. Lewis's experiments we find, that liver of sulphur is capable of dissolving platina, as it does also gold, by fusion. Mr. Margraaf's experiments leave this matter uncertain: but if, as we have reason to believe, liver of sulphur does dissolve platina, this is another instance of the conformity of this metal with gold.

Almost all metallic substances are capable of separating platina from aqua regia, as they also separate gold. Platina precipitated by these substances has its metallic appearance. In this respect it conforms with a general rule, that metals precipitated by other metals have their metallic appearance. See PRECIPITATION.

Mr. Margraaf relates, in his Memoir, a great number of experiments which he made to discover the effects of mixing a solution of platina with other metallic solutions, and also of digesting pure platina with these solutions and other saline substances. These experiments furnished many curious and interesting facts; but as several of them do not seem to be consistent with the essential and ascertained properties of platina, nor even with similar experiments made by other chemists, we have reason to believe that these singularities observed by this able chemist proceeded from some extraneous matters with which his platina was

(1) Mr. Margraaf mentions a very singular fact concerning the precipitation of platina by alkalis; namely, that although vegetable fixed alkali, and even volatile alkali, precipitated this metal from aqua regia; yet the mineral alkali, though in other instances equal in power of union to the former alkali, and superior to the latter, produced no precipitation, even when so much of it was added as to saturate the acid, nor even disturbed the transparency of the liquor.

allayed. From most of these experiments, as, for instance, from the yellow flowers obtained by subliming platina with sal ammoniac, and from the blue precipitate formed by mixing his solution of platina with a lixivium of Prussian blue, we may conclude, that iron was the metal with which his platina was allayed, as he himself says.

Platina, like gold, is capable of being allayed with all metals, and in these allays exhibits interesting phenomena. Dr. Lewis has examined these allays more carefully and fully than any other person. As we have said nothing of it under the article ALLAY, we shall summarily mention here what Dr. Lewis has observed on this subject.

Platina, although very unfusible when alone, may however be fused along with other metals with which it is capable of combining. Equal parts of gold and platina may be melted in a violent fire, and the allay which is formed may be easily poured into an ingot mould. It is whitish, hard, and may be broken by a violent blow. Nevertheless, when it has been well annealed, it is capable of considerable extension under the hammer. One part of platina and four parts of gold may be melted and allayed with a much less fire than is requisite in the preceding experiment. This allay is so ductile, that it may be extended into very thin plates without being broken, or even split at the edges. Dr. Lewis observed a remarkable circumstance concerning this allay, namely, that the platina, which was  $\frac{1}{5}$  of the whole mass, rendered the gold no paler than guineas are, which contain only  $\frac{1}{15}$  of silver.

Silver and platina may be melted and allayed together in equal parts with a very violent fire. The allay which is formed is much harder and darker-colored than silver, and of a large grain, although it preserves some ductility. These qualities are less sensible when one part of platina is added to seven parts of silver: but this allay is still coarser-grained and less white than silver. This coarseness of grain shews an imperfect union; and indeed silver and platina do not seem to unite very intimately; for Dr. Lewis observes, that when the allay of these two metals was left after fusion in the crucible, a considerable part of the platina was separated and sunk to the bottom. The platina did not appear to communicate any good quality to the silver, excepting a greater hardness.

Copper seems to be most improved by being allayed with platina. When indeed a large proportion of platina is added to copper, as equal parts or two-thirds, the allay is hard, brittle, and coarse: but when a less quantity of platina is added, as from  $\frac{1}{5}$  to  $\frac{1}{15}$ , or even less, a golden-colored copper is produced, very malleable, harder, susceptible of a finer polish, smoother-grained, and much less subject to calcination and rust than pure copper.

Dr. Lewis was not able to fuse forged iron with platina, which is not surprising, when we consider the refractory qualities of these two metals: but he allayed platina with cast-iron, by throwing one part of platina to four parts or more of the iron when it was just beginning to flow. This allay was much harder, and much less subject to rust, than pure iron. It was susceptible of a very fine polish.

Platina may be melted with tin in all proportions from equal parts of the two metals to twenty-four parts of tin. This allay was observed to be so much harder, more brittle, more dark-colored, and coarser, as the proportion of the platina

platina was larger. No advantage seemed to be acquirable by this alloy. Lead also may be alloyed in different proportions with platina, nearly as tin may, with this difference, that a much greater fire is necessary for the formation of this latter alloy, particularly when the quantity of platina is great. The metal resulting from it has a dark color, somewhat approaching to a purple or violet, or it easily acquires these colors when exposed to the air. When the two metals fused together are left in a crucible to cool, a considerable part of the platina separates and falls to the bottom, in the same manner as it does from the alloy of silver.

From Dr. Lewis's experiments platina appears to be capable of amalgamating with mercury, but difficultly, and by a very long trituration with water, as, for instance, during a week.

If mercury be triturated with an alloy of gold and platina, it seizes the gold, and does not touch the platina. Dr. Lewis proposes this amalgamation as a method of separating these two metals; and it is that which is employed in the ores of Peru, in which gold and platina are mixed together: but we do not yet know whether this separation be perfectly complete.

Platina may be alloyed with bismuth nearly as with lead, and in a similar manner separates from the bismuth after fusion. It gives to bismuth also, as it does to lead, the property of acquiring, by exposure to air, violet, purple, or blue colors. This alloy is always very brittle.

Of all metallic matters zinc may be most easily alloyed with platina, and most effectually dissolved by fusion. Dr. Lewis observed, that these alloys did not appear very different from pure zinc; but that when the proportion of platina is considerable, their grain is closer, their color less clear, and more bluish than of zinc. They do not tarnish, nor change colors, by exposure to air. Lastly, they are harder than zinc, and have not the semi-malleability of this semi-metal.

With regulus of antimony platina formed a darker and harder compound than the pure regulus.

Dr. Lewis has combined platina at the same time with two metallic matters, such as with brass composed of copper and zinc, and with bronze composed of copper and tin. The most singular phenomenon of this latter alloy was, that the copper and tin acting conjointly upon the platina was capable of dissolving more of it than they both could do separately. This alloy was hard and capable of receiving a fine polish, but is subject to tarnish, which seems to happen to all the alloys of tin or of lead with platina.

Equal parts of platina and brass formed a compound very hard and very brittle, capable of receiving a very fine polish, and not subject to tarnish. It might therefore be employed for speculums of telescopes, and would be much preferable to those now used, all which have the great disadvantage of tarnishing by exposure to air, and even very quickly.

Dr. Lewis does not mention the effects of alloying platina with arsenic; but Mr. Scheffer affirms, that if only a twentieth part of arsenic be added to platina when red-hot in a crucible, these two substances will be perfectly fused, and will form a brittle, grey mass. This remarkable experiment requires confirmation: for Mr. Margraaf having also treated these two matters together, did not perceive any such action of arsenic upon platina. From one of his experiments



we find, that having exposed to a violent fire during an hour a mixture of an ounce of platina with a fusible glass composed of eight ounces of minium, two ounces of flints, and one ounce of white arsenic, he obtained a regulus of platina, well united and fused, which weighed an ounce and thirty-two grains, the surface of which was smooth, white and shining, and the internal parts grey, but which nevertheless appeared sufficiently white when it was filed.

The cupellation of platina was one of the most important experiments to be made; because if this operation succeeded perfectly, we might thereby obtain compact and malleable masses of pure platina, in the same state as a metal which had been well fused, and of which all sorts of utensils might be made, if not by casting it, at least by forging. All the chemists who have examined this metal, and particularly Dr. Lewis, have used their utmost endeavours to cupel it well. But although they have used every expedient to apply the strongest heat, they have not perfectly succeeded. The scorification proceeds well at the beginning of the operation, as when gold and silver are cupelled: but the cupellation afterwards becomes more and more difficult; because, as the quantity of lead diminishes, the matter becomes less and less fusible, and at last ceases to be fluid, notwithstanding the most violent heat; and also because, when the quantity of platina is greater than that of the lead, this latter metal is protected, and is not converted into litharge. Hence the regulus obtained is always dark-colored, rough, adhering to the cupel, brittle, and weighing more than the platina originally employed, from the lead which remains united with it. Messrs. Macquer and Beaumé appear nevertheless to have carried this experiment further than any other chemists, as they kept the matter exposed to a violent fire during a longer time, that is, about fifty hours successively; therefore, although their platina was tarnished and rough on its surface, it was internally white and shining, easily separable from the cupel, and a little diminished in weight, a certain proof that no lead remained in it. This platina was also ductile, and capable of extension under the hammer. Cupellation is therefore a certain method of applying platina to use, and of forming it into utensils.

The sciences, commerce, and arts must receive great advantages from the application of a new perfect metal to useful purposes, which to the fixity and indestructibility of gold unites a hardness and solidity almost equal to those of iron; which is unalterable by the action of water and air; is not subject to rust; and resists as well as glass or earthen vessels all salts, even aqua fortis and other pure acids. We regret, that although large quantities of it are found in America, it is so exceedingly rare here.

The cause of this great scarcity of platina is, that the Spanish Ministry have prohibited the sale of it, or the extraction of it from the mines. These prohibitions were certainly from good motives and wise intentions; for this metal was no sooner known than it was employed for the adulteration of gold, for which purpose it is very fit, as it sustains all the ordinary trials of gold, has the same specific gravity, and renders gold much less pale than silver. The use of a metal with which frauds so prejudicial might be committed with impunity was necessarily interdicted: but since the best chemists of Europe have examined platina, they have published certain and easy methods by which the smallest quantity of platina mixed with gold may be discovered, and by which these metals



metals may be separated, in whatever proportion they may happen to be united. These methods may be seen in the Memoirs of the chemists who have examined this matter. We shall here relate only one of the most convenient and least troublesome. It is founded on a property which gold has, and not platina, of being capable of precipitation from aqua regia by martial vitriol; and upon a property which platina has, and not gold, of being capable of precipitation from aqua regia by sal ammoniac. When therefore we would discover if gold be allayed with platina, let it be dissolved in aqua regia, and to this solution, which will contain both metals, let some sal ammoniac dissolved in water be added, upon which the platina will be precipitated in form of a brick-colored sediment. If, on the other side, we would know if platina contained any gold, let this platina be dissolved in aqua regia, and to the solution add a solution of martial vitriol in water, upon which the liquor will become turbid, and the gold will form a precipitate which may be easily separated by decanting and filtrating the liquor.

We may then affirm, that the reasons which induced the Spanish Ministry to interdict the use of platina no longer subsist; and we hope that when they are once convinced of this, society shall no longer be deprived of a substance which may be so advantageous to them, and which may be a new source of wealth to the Crown of Spain, the sole proprietor of this precious treasure.

**DXLV. PLUMBUM CORNEUM.** This is a combination of lead with marine acid. It is a metallic salt which may be made by combining directly lead with that acid: but this process is not much used, because others are more convenient. For instance, by pouring some marine acid, or the solution of a salt containing it, into a solution of lead made by the nitrous acid, we obtain a plumbum corneum, which falls down to the bottom of the vessel, if the liquor does not contain too much water. A similar combination may be made by distilling calxes of lead, as minium, for instance, with sal ammoniac. The lead disengages the volatile alkali of this salt, and unites with its acid, which is the same as that of common salt.

Lead united with marine acid has some resemblance to luna cornea, which is a combination of silver with the same acid; and hence has been called plumbum corneum. Like the luna cornea, it is semi-volatile and crystallizable, but is infinitely more soluble in water. This combination is not used in the arts, and little in chemistry. *See LEAD.*

**DXLVI. POMPOLIX.** This is one of the names given to the flowers of zinc sublimed during the deflagration of this semi-metal. *See FLOWERS of ZINC and ZINC.*

**DXLVII. PORCELAIN.** Porcelain is the most beautiful and finest of all earthen wares. All earthen wares which are white and semi-transparent are generally called porcelains: but amongst these so great differences may be observed, that notwithstanding the similarity of their external appearance, yet when they are examined chemically, they cannot be considered as matters of the same kind. These differences are so evident, that even persons who are not connoisseurs in this way prefer much the porcelain of some countries to that of others.

As the several kinds of porcelain differ so much from each other, no general process can be given for making it. We ought therefore to confine ourselves

to describe and consider the manufacture of some particular porcelain, remarkable for its excellence and beauty. But this also is almost impracticable; because in all the manufactories where it is made, both in France and other countries, the ingredients and method of preparation employed are carefully concealed. Nevertheless, we have a general knowledge of the principal operations of this manufacture, which we shall here deliver; and that we may supply the details which we cannot describe, we shall give our opinion concerning the qualities which the best porcelain ought to have. This seems to be necessary, as the manufacture of porcelain is an object more attended to than ever; and as many persons, otherwise intelligent, talk and judge of it without having any precise notions on the subject.

The art of making porcelain is one of those in which Europe has been excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even the magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans. I shall not here relate the histories of the several attempts made in Europe to imitate the oriental porcelain, as most of them are unknown, and would lead us too far from the subject. I shall only say, that in different parts of Europe, earthen wares have been made so like the oriental that they have acquired the name of porcelain. Neither shall I inquire into the æra of the establishment of the several manufactures of porcelain in Europe. I shall only say, that I believe the first European porcelains were made in Saxony and in France; and afterwards in England, Germany, and Italy. But as all these were different from the Japanese, so each of them had its peculiar character.

We now proceed to determine the quality of the principal porcelains, namely, those of Japan or of China, of Saxony and of France.

The illustrious Reaumur first attended to this object, and communicated his researches in two Memoirs before the Academy of Sciences in 1727 and 1729. This great experimental philosopher took the best method of arriving at a thorough knowledge of the subject; and although he was mistaken in some points, and altho' he neglected to consider some of the essential qualities requisite to constitute good porcelain, he is nevertheless the first person who published any distinct notions upon the subject. He did not satisfy himself with considering the external appearance, the painting and gilding, which are only ornaments not essential to the porcelain, but he endeavored to examine it internally: And having broken pieces of the Japanese, Saxon, and French porcelains, he examined the difference of their *grains* (which name is given to their internal structure). The grain of the Japanese porcelain appeared to him to be fine, close, compact, moderately smooth, and somewhat shining. The grain of the Saxon porcelain was found to be still more compact, not granulous, smooth, shining like enamel. Lastly the porcelain of St. Cloud had a grain much less close and fine than that of Japan, not, or but little shining, and resembling the grain of sugar.

From these first observations Mr. Reaumur perceived that porcelains differed considerably. That he might examine them further, he exposed them to a violent heat. More essential differences than those of the grain appeared upon this

this trial; for the Japanese porcelain was unaltered by the fire, and all the European were melted, as Mr. Reaumur says.

This essential difference betwixt the Japanese and European porcelains suggested to Mr. Reaumur a very ingenious thought, and in many respects true, concerning the nature of porcelain in general. As all porcelains somewhat resemble glass in consistence and transparency, tho' they are less compact and much less transparent, Mr. Reaumur considered them as *semi-vitrifications*. But every substance may appear, and may actually be in a semi-vitrified state in two manners: for, first, it may be entirely composed of vitrifiable or fusible matters; and in this case, by exposing it to the action of fire, it will be actually melted or vitrified, if the heat be sufficiently strong and long-continued. But as this change is not made instantly, especially when the heat is not very violent, and as it passes through different stages or degrees, which may be more easily observed as the heat is better managed; hence, by stopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate state betwixt those of crude earths and of completely vitrified substances; and also possessed of the semi-transparency and of the other sensible qualities of porcelain. We know also, that if such porcelain be exposed to a stronger degree of fire, it will then be completely fused and entirely vitrified. But most of the European porcelains have this fusibility, from which Mr. Reaumur concludes, that their composition is founded upon the above-mentioned principle.

In the second place, a paste of porcelain may be composed of fusible and vitrifiable matter, mixed with a certain proportion of another matter which is absolutely unfusible in the fires of our furnaces. We may easily perceive, that if such a mixture be exposed to a heat sufficient to melt entirely the vitrifiable ingredient, that this matter will actually melt; but as it is intermixed with another matter which does not melt, and which consequently preserves its consistency and opacity, the whole must form a compound partly opaque and partly transparent; or rather a semi-transparent mass; that is, a semi-vitrified substance, or porcelain, but of a kind very different from the former; for as the fusible part of this latter has produced all its effect, and as it has been as much fused as it can be during the baking of the porcelain, the compound may be exposed a second time to a more violent fire without approaching nearer to a complete vitrification, or without departing from its state of porcelain. But as oriental porcelain has precisely these appearances and properties, Mr. Reaumur concludes with reason, that it is composed upon this principle; and he afterwards confirmed his opinion by undeniable facts.

Father *Entrecolles*, missionary at China, had sent from thence a summary description of the process by which the inhabitants of that country make their porcelain; and also a small quantity of the materials which they employ in its composition. He said that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them *petuntse*, which they carefully grind to a very fine powder; and the other, called by them *kaolin*, is a white, earthy substance, which they mix intimately with the ground *petuntse*. Mr. Reaumur examined both these matters, and having exposed them separately to a violent fire, he discovered that the *petuntse* had fused without addition, and that the *kaolin* had given no sign of fusibility. He afterwards

afterwards mixed these matters, and formed cakes of them, which by baking were converted into porcelain similar to that of China. Mr. Reaumur easily found that the petuntse of the Chinese was a hard stone of the kind called vitrifiable, but infinitely more fusible than any of these which were known in Europe; and that the kaolin was a talky matter, reduced to very fine powder (*m*). From that time he hoped to make a porcelain of the same kind as the Chinese with materials found in France. Whether he could not find any materials equal to those of China, particularly that material analogous to the petuntse of the Chinese, or because other occupations prevented the continuance of his researches, we do not know; but we find, from his second Memoir upon porcelain, that he afterwards attempted to make an artificial petuntse, by mixing our vitrifiable stones with salts capable of rendering them fusible, or even by substituting for it glass ready formed, and by adding to these such substances as he thought might be substituted for kaolin. But he probably found he could not execute these intentions, for he did not resume this subject from the year 1729 to 1739,

(*m*) The *petuntse* is improperly ranked amongst the class of earths called vitrifiable, because it is fusible without addition, and because it is not hard enough to elicit sparks from steel; whereas the vitrifiable or siliceous earths are unfusible by fire, unless they contain some metallic mixture, and are very hard. Authors have not described very distinctly the petuntse; some believing it to be an alkaline spar, and others the rhomboidal quartz, called *felspar*. But from the later accounts, and from a knowledge of some experiments that have been made successfully concerning porcelain, I believe that the petuntse is different from both these substances, and that it is a white opaque fluor. At least I have seen excellent porcelain made with such a fluor together with a white argillaceous earth. The texture of this fluor was laminated, its figure was indeterminate, it was rendered luminous in the dark by friction, it was fusible by violent heat, it was not sufficiently hard to elicit sparks from steel, and it was indissoluble by acids. It seems to be of the same kind as the Bolognian stone, and the white heavy fluors, which, as Mr. Margraaf found, are capable of acquiring by calcination with inflammable matter the property of absorbing light. See PHOSPHORIC STONES. Mr. Scheffer's examination of Chinese petuntse, published in the Swed. Trans. 1753, corresponds with the above account, excepting that his specimen appears to have had a greater transparency than the fluor above described, and to resemble the lapis specularis, which also possesses the phosphoric property

of the Bolognian stone, and contains, according to Mr. Margraaf's experiments, nearly the same principles as that stone and the heavy white fluors above described. See PHOSPHORIC STONES. I do not, however, mean to affirm that no porcelain can be made without such a fluor. I am inclined to believe that porcelains may be made of other materials besides a clay or kaolin, and a white fluor or petuntse. One of the ingredients of the Saxon porcelain is a beautiful white stone, which is not fusible by a most violent heat. See Mr. D'Arcet's Memoir sur l'Action d'un Feu Violent, &c. Mem. de l'Acad. des Sc. 1766. Pure clays singly, or mixed with finely-ground siliceous earth, acquire by violent heat the hardness and all the properties, excepting the semi-transparency, of porcelain.

The *kaolin* of the Chinese is a white argillaceous earth, sometimes intermixed with particles of mica, and, as Mr. Bomare affirms, sometimes with particles of quartz and of calcareous earth. But the quantity of the last substance must be very small, as it would render the argillaceous earth fusible, and consequently unfit for the purpose of a kaolin. Mr. Guettard, who has written a Memoir upon the ingredients of Porcelain (Mem. of the Acad. of Sciences, 1765) describes the kaolin as a white argillaceous earth without any calcareous mixture. Probably the calcareous particles found in the specimen analysed by Mr. Bomare, and perhaps also the particles of quartz and of mica, are not necessary and constant parts of kaolin.

when

when he gave a process for converting common glass to a singular kind of porcelain, to which he has given his name, and of which we shall treat in the following article.

Although Mr. Reaumur has not exhausted entirely this subject, he has surmounted many difficulties, and has given just notions concerning it: In a word, he has opened the road for all those who afterwards engaged in this pursuit, and has therefore a right to share the honor of the important discoveries which have been since made by others.

But as a person who first unravels so intricate and hidden a matter as the manufacture of porcelain, can scarcely discover every thing concerning his subject, so Mr. Reaumur has been mistaken, or rather misled in two important points. His first error concerns the Saxon porcelain, which he confounds with the other fusible porcelains made in Europe. I do not know whether formerly a porcelain was made in Saxony, composed entirely of fusible or vitrifiable materials, the vitrification of which was stopt in proper time. Possibly this was the first kind of porcelain made in that country, and which Mr. Reaumur had examined. But I am certain that I have never seen any such Saxon porcelain, and that all of that country which I have examined was capable of resisting the most violent fires without fusion, as well, at least, as those of China and Japan. Mr. Reaumur might have been misled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal surface does not appear granulous, but compact, uniform, smooth, shining, and much resembling white enamel. But this appearance, so far from shewing that Saxon porcelain is a fused or vitrified substance, proves that it is not entirely composed of fusible matters. All who have considered attentively this subject know that the internal surface of the most fusible porcelains is also the least dense and least compact: the reason of which is, that no vitreous matter can be smooth and dense internally, unless it has been completely fused. But if the density and shining appearance of the internal surface of the Saxon porcelain were only the effects of the fusion of a vitreous matter, how could we conceive that vessels formed of that matter should have sustained the necessary fusion for giving this density and shining appearance, without having entirely lost their shape? The impossibility of this is evident to any persons who have been conversant in these matters, and in the fusion of glass.

This quality of the Saxon porcelain must therefore proceed from another cause. It does indeed contain, as every porcelain does, particularly those of China and Japan, a fusible substance, which has been even completely fused during the baking. Its density also and its internal lustre proceed chiefly from this fused matter; but we are also certain that it contains a large quantity of a substance absolutely unfusible, from which it receives its admirable whiteness, its firmness and solidity, during the baking; in a word, which supplies the place of the oriental kaolin, and which has the property of contracting its dimensions considerably while it incorporates with the fusible substance. If it be subjected to the most decisive trial, namely, the action of a violent fire, capable of melting every porcelain composed of fusible matters alone, I affirm, after many experiments, that it cannot be fused, unless by a fire capable also of melting the best Japanese porcelain. The Saxon porcelain is therefore not to be confounded with those which are vitreous and fusible, but is in its kind

as excellent as that of Japan, and perhaps superior, as we shall see when we enumerate the qualities which constitute the excellence of porcelain. The subject of Mr. Reaumur's second error, or, at least, that which he has not sufficiently explained, is the *kaolin* of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntse, the oriental porcelain is formed. Possibly a very finely-ground talky substance mixed with petuntse might form a porcelain similar to the oriental; but persons acquainted with the manufacture of any porcelain, must perceive the impossibility of forming vessels, unless the paste of which they are made be so ductile and tenacious, that it may be worked upon a potter's lathe, or at least that it may be moulded. But talks or any kinds of stones, however finely ground, cannot acquire the requisite tenacity, which clays only, of all known earthy substances, possess. The Chinese porcelain vessels evidently appear to be turned upon the lathe, since they retain the marks of it; hence they must have been formed of a very tenacious paste, and consequently the kaolin is not a purely talky matter, but is mixed with clay; or else the petuntse and kaolin are not, as Mr. Reaumur supposes, the only ingredients of the paste of which Chinese porcelain is formed, but a sufficient quantity of some binding matter, unknown to father d'Entrecolles and Mr. Reaumur, must be also added.

Although, since Mr. Reaumur, no scientific person has written concerning porcelain, many have attempted to make it. Manufactures have been established in almost all the states of Europe. Besides that of Saxony, which has been long established, porcelain is also made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All these German porcelains are similar to the Saxon, and are made of materials of the same kind, although they differ somewhat from each other. England and Italy also have their porcelains, the chief of which are those of Chelsea and of Naples. Mr. de la Condamine, in his last journey into Italy, visited a manufacture of porcelain established at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine observed particularly the large size of some pieces of this porcelain. He says he saw statues and groupes half as large as nature, modelled from some of the finest antiques. The furnaces in which the porcelain was baked were constructed with much art, and lined with bricks made of the porcelain materials. The paste of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the best Chinese porcelain. A whiter glazing would be desirable, which they might probably attain, if the Marquis Ginori was not determined to use those materials only which were found in that country.

But in no state of Europe have such attempts been made to discover porcelain, or so many manufactures of it been established, as in France. Before even Mr. Reaumur had published on this subject, porcelain was made at Saint Cloud, and in the suburb of St. Antoine at Paris, which was of the vitreous and fusible kind, but considerably beautiful. Since that time, considerable manufactures of it have been established at Chantilly, at Villeroy, and at Orleans; the porcelains of which have a distinguished merit. But certainly the admirable works produced in the King's manufacture at Sevres does most honor to France. This porcelain holds at present the first rank, from its shining white, its beautiful glazing, and colored grounds, in which no porcelain has ever

ever equalled it. The magnificence of the gilding, the regularity and elegance of its forms, surpasses every thing of the kind. In the painting and sculpture much genius and talents are displayed. We cannot commend this work more, than by mentioning that Messrs. Bachelier and Falconet preside and direct it. Lastly, as all the operations of this truly great and royal establishment are directed by men of known capacity, assisted by philosophical and chemical researches, this manufacture is upon the point of producing porcelain capable of emulating or equalling the most perfect and most solid works of this kind (*n*). We ought also to give due praises to several of our contemporaries and countrymen, who have distinguished themselves in their attempts in this way. Mr. Guettard, physician of the Faculty at Paris, an able naturalist of the Academy of Sciences, and who has particularly applied himself to the study of earths and fossils, seems to have been one of the first who, since Mr. Reaumur, pretended to have found in France a kaolin and petuntse of the same nature as the Chinese.

Mr. Guettard has lately published an account of his discoveries on this subject, in the Memoirs of the Academy of Sciences for the year 1765. The kaolin which he employed was a white argillaceous earth, filled with mica, which he found in the neighbourhood of Alençon; and his petuntse is a hard, quartzose grit stone (*o*), found abundantly in the same country, with which the streets of Alençon are paved. We also know that Mr. Guettard had begun to make his experiments on porcelain with these materials in the year 1751, together with the late Duke of Orleans, to whom he was attached. The Count de Lauraguais, of the Academy of Sciences, who has acquired a distinguished reputation in chemistry by several excellent discoveries, on the acetous ether, on the solution of sulphur by spirit of wine, on the inflammation and crystallization of radical vinegar, &c. engaged in the pursuit of porcelain for several years with uncommon ardor and constancy. He spared no trouble nor expence to attain his purpose, which was to make porcelain equal in all respects to that of China and Japan. He shewed some pieces made by him, in the year 1766, to the Members of the Academy of Sciences. The persons appointed by them to examine it gave their opinion, that of all the porcelains made in this country, that of the Count de Lauraguais most resembled the

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porcelain of China and Japan in solidity, grain, and unfusibility. It were to be wished that it possessed equally the other qualities essential to the excellence of porcelain, namely, the whiteness and lustre observable in the ancient Japanese porcelain (*p*).

We shall not here particularly examine the qualities of the several porcelains now known. We shall only shew what those qualities are which constitute the perfection of porcelain. We must first carefully distinguish the qualities which only contribute to beauty and external appearance, from the intrinsic and essential properties in which the goodness and solidity of porcelain consist. All persons who have made experiments in this way have soon discovered the possibility of making compounds very white, beautifully semi-transparent, and covered with a shining glazing, but which cannot be worked for want of tenacity, are not sufficiently compact, are essentially fusible, are subject to break by sudden application of heat and cold; and, lastly, the glazing of which cracks, becomes rough, and consequently loses its lustre by use, because it is too soft.

On the other side, we shall also find it not difficult to compose very tenacious pastes, which shall be capable of being easily worked and well baked, which in the baking shall acquire the desirable hardness and density, which are unfusible, and capable of sustaining very well the sudden change of heat and cold; and, in a word, which shall have all the qualities of the most excellent porcelain, excepting whiteness and beauty. We shall soon see that the materials fit for the composition of such porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodness in one composition. I acknowledge that nature seems to be very sparing of materials fit for this purpose, and therefore perfect porcelain will always be a dear and valuable commodity.

Many will be surprized when I affirm, that before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made here equal in goodness and in essential qualities, and was universally used and even sold very cheap. For those potteries which we call *grais* or *stone-ware* are not of modern invention, and have all the essential qualities of the best Japanese. For if we except whiteness, on which alone the semi-transparency depends, and compare all the properties of Japanese porcelain with those of our stone-ware, no difference can be found betwixt them. The same grain appears internally in both; the same sound is produced by striking them when properly suspended; the same density; the same hardness, by which they strike fire with steel; the same faculty of sustaining the heat of boiling liquors without breaking, and the same unfusibility in fire, are observable. Lastly, if the earths of which stone-ware is made were free from heterogeneous coloring matters, which prevent their whiteness and semi-transparency; if vessels were carefully formed; if all the proper attentions were given; and if these vessels were cover-

(*p*) The porcelain made by that ingenious and scientific nobleman is said to have possessed the intrinsic excellencies of porcelain, as eminently, at least, as even the Saxon or oriental. A gentleman of undoubted veracity has assured me, that when

the Count de Lauraguais was a few years ago in England, he saw him heat a piece of his porcelain till it was red-hot, and then throw it into cold water, without breaking or cracking it.

ed over with a fine glazing; they would be as perfect porcelain as that of Japan. The most perfect porcelain, therefore, is nothing else than a fine white stone-ware. (q)

Earths of this kind are probably more rare in Europe than in Japan and China. And probably also the want of these earths was the cause that the first makers of porcelain in this country confined themselves to an external imitation, by employing nothing but vitrifiable matters with fusible salts and a small quantity of white earth, from which fusible and vitreous porcelains were composed, which might be called *false porcelains*. But things are much changed since these first attempts. Besides the discoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains have been made a long time ago in Germany, especially in Saxony and at Frankendal. The new porcelain, a trial of which is just finished at the King's manufacture, is of this kind. (r)

These porcelains are not inferior in any respect to the oriental; they are even much superior in beauty and whiteness to the modern oriental porcelain, which has much degenerated in these respects; they seem even to excel the oriental in the most valuable quality of porcelain, namely, the property of sustaining the sudden change of heat and cold. We cannot judge of the quality of porcelain by a slight trial; for so many circumstances concur to make a piece of porcelain capable or incapable of sustaining the sudden application of heat and of cold, that if at the same time boiling water be poured into two vessels, one of which is good porcelain and the other bad, the former may possibly break, and the latter remain entire: the only true method of discovering good porcelain in this respect is, to examine several pieces of it which are daily used, for instance, a set of coffee-cups. But I have observed that in many such pieces of oriental porcelain, which have been long and daily used, cracks in the direction of their height may be always perceived, which are never seen in the good European porcelains.

Every one talks of porcelain, and yet few are connoisseurs of it. None can be considered as such but those who have long made it an object of their inquiries. That the ancient Japanese porcelain is the most perfect, is a general opinion. This porcelain is indeed very beautiful, and we must also acknowledge that its quality is excellent. It has been our model, and has long been the object of our admiration and emulation; but which we have been never able to equal, and which many persons believe never can be equalled. Some persons even decry the Saxon porcelain for a quality which really gives it a superiority to the Japanese, namely, the greater smoothness, lustre, and less granulous appearance of its internal surface than the oriental. The resemblance of this

(q) The French stone ware, or *potterie de grès*, is formed of a whitish clay, in which a good deal of fine white sandy particles are intermixed. The English *stone-ware* is composed of tobacco-pipe clay and ground flints. This ware, when sufficiently burnt, has, as well as the French, the qualities of porcelain which the author calls essential, namely, strength, hardness, the property of

sustaining the heat of boiling water, and unfusibility. See POTTERY.

(r) I have nevertheless seen several pieces of the porcelain of Sévres, lately brought from thence, which were not of the kind called by the author *genuine*, but which had the properties and defects mentioned in the above note (n).

surface to that of glass has evidently suggested this notion; and it would be well founded, if the density and lustre of this porcelain proceeded only from a fusible and vitreous quality; but as they do not, and as this porcelain is as fixed and as unfusible as the Japanese, its density, so far from being a fault, is a valuable quality. For we must allow, that of porcelains equal in other respects, those are best which are most firm and compact. Hence, the interior substance of the Japanese porcelain is esteemed for its greater density, compactness and lustre, than our vitreous or fritt porcelains, because these qualities indicate greater cohesion, and more intimate incorporation of its parts. For the same reason also the superior density of the Saxon porcelain ought to give it the preference to the Japanese. Besides, nothing would be easier than to give the Saxon porcelain the granulous texture of the Japanese, by mixing with the paste a certain quantity of sand. But the persons who perfected that manufacture were certainly sensible, that such a conformity to the Japanese porcelain would lessen the merit of theirs. For we know, that in general porcelains are better in proportion as they contain a larger proportion of clay or earth, and less of sand, flints, or other matters of that kind.

What we have said concerning porcelain in general, and the principal kinds of it, seems sufficient to give just notions of it, if not to persons who without considering the subject are determined to prefer the most ancient, to those, at least, who have made experiments on this subject, or who, having a sufficient knowledge of chemistry, are capable of studying and examining it thoroughly. We shall finish this article by giving a short description of the method of manufacturing porcelain.

The basis of the porcelains which we have called fusible, vitreous, or false porcelains, is called by artists a *fritt*; which is nothing else than a mixture of sand or of powdered flints, with salts capable of disposing them to fusion, and of giving them a great whiteness by means of a sufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is sufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a paste, which is to be formed, either upon the wheel or in moulds, into pieces of such forms as are required.

Each of these pieces when dry is to be put into a case made of earthen ware (s); which cases are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with these to the roof. The furnaces are chambers or cavities of various forms and sizes, and are so disposed that their fire-place is placed on the outside opposite to one or more openings, which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying, determines a current of air from without inwards, as in all furnaces. At first a very little fire is made, that the furnace may be heated gradually, and is to be increased more and more, till the porcelain is baked,

(s) The cases are called by English potters, *feggars*. They are generally formed of coarser clays, but which must be also capable of sustaining the heat required without fusion. By means of these cases, the contained porcelain is preserved from the smoke of the burning fuel. The whiteness of the porcelain depends much on their compactness of texture by which the smoke is excluded, and on the purity of the clay of which they are made.

that

that is, till it has acquired its proper hardness and transparency; which is known by taking out of the furnace from time to time, and examining, small pieces of porcelain, placed for that purpose in cases which have lateral openings. When these pieces shew that the porcelain is sufficiently baked, the fire is no longer to be supplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this state resembles white marble not having a shining surface, which is afterwards to be given by covering them with a vitreous composition, called the *glazing*.

The porcelain when baked and not glazed is called *biscuit*, which is more or less beautiful according to the nature of the porcelain. The manufacture of Sévres excels all others in this respect, and it is therefore the only one which can produce very fine pieces of sculpture; that is, in which all the fineness of the workmanship is preserved, and which are preferable in smoothness and whiteness to the finest marble of Italy.

If this porcelain had no other merit, it would be sufficient to induce true connoisseurs to prefer it to any other matter, however solid, without this advantage.

As no piece of sculpture of this kind can preserve all the delicacy of its workmanship when covered with a glazing; and as sculptors avoid polishing their marble figures, because the lustre of the polish is disadvantageous; therefore in the manufacture of Sévres, all figures, or little statues, and even some ornamental vases, are left in state of *biscuit*. The other pieces of porcelain are to be glazed in the following manner.

A glass is first to be composed suited to the nature of the porcelain to which it is to be applied, for every glass is not fit for this purpose. We frequently find that a glass which makes a fine glazing for one porcelain shall make a very bad glazing for another porcelain, shall crack in many places, shall have no lustre, or shall contain bubbles. The glazing then must be appropriated to each porcelain, that is, to the hardness and density of the ware, and to the ingredients of its composition, &c.

These glazings are prepared by previously fusing together all the substances of which they consist, so as to form vitreous masses. These masses are to be ground very finely in a mill. This vitreous powder is to be mixed with a sufficient quantity of water, or other proper liquor, so that the mixture shall have the consistence of cream of milk. The pieces of porcelain are to be covered with a thin stratum of this matter, and when very dry they are to be again put into the furnace, in the same manner as before, for the forming of the *biscuit*, and to be continued there till the glazing be well fused. The necessary degree of fire for fusing the glazing is much less than that for baking the paste.

The pieces of porcelain which are intended to remain white are now finished; but those which are to be painted and gilded must undergo further operations. The colors to be applied are the same as those used for enamel painting. They all consist of metallic calxes bruised and incorporated with a very fusible glass. Crocus of iron furnishes a red color; Cassius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; saffre makes the blue; earths slightly ferruginous produce a yellow; and, lastly, brown and black colors are produced by calcined iron, together

together with a deep blue of zaffre. These colors being ground with gum-water, or with oil of spike, are to be employed for the painting of the porcelain with designs of flowers and other figures (*t*). For gilding, a powder or calx of gold is to be applied in the same manner as the colored enamels (*u*). The painted and gilded porcelains are to be then exposed to a fire capable of fusing the glass, with which the metallic colors are mixed. Thus the colors are made to adhere, and at the same time acquire a gloss equal to that of the glazing. The gold alone has not then a shining appearance, which must be afterwards given to it by burnishing with a blood-stone.

The operations for the unfusible porcelains, and also for such as are of the nature of stone-ware, are somewhat more simple. The sands and stones which enter into their composition are to be ground in a mill: the earths or clays are to be washed: the materials are to be well mixed and formed into a paste: the pieces are first rudely formed upon a potter's wheel; and when dry or half dry, they are turned again upon the wheel, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a sufficient heat to give them such a solidity that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this slight heat are very dry, they imbibe water readily. This disposition assists the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previously ground in a mill, is to be mixed with such a quantity of water, that the liquor shall have the consistence of milk. The pieces of porcelain are hastily dip't in this liquor, the water of which they imbibe, and thus on their surface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very soon become so dry, that it cannot stick to the fingers when the pieces are handled.

The pieces of this porcelain are then put into the furnace to be perfectly baked. The heat is to be raised to such a height, that all within the furnace shall be white, and the cases shall be undistinguishable from the flame. When, by taking out small pieces, the porcelain is known to be sufficiently baked, the fire is discontinued, and the furnace cooled. If the baking has been well performed, the pieces of porcelain will be found by this single operation to be rendered compact, sonorous, close-grained, moderately glossy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner similar to that already described. (*x*)

(*t*) See the article ENAMEL, and the Note subjoined.

(*u*) The several powders of gold employed for this purpose are described in a note subjoined to the article GILDING.

(*x*) I purposely avoid giving any opinion concerning the relative advantages and defects of the porcelains of British manufacture. I shall only add, that we have reason to believe, that the materials of genuine porcelain might be discovered in this island, if search were made by intelligent persons. The steatites or soap-rock of Corn-

wall is probably a good kaolin; and I have sometimes found stones in England in which the white opaque fluor above described was blended with a pure quartz, and which I am well convinced might be successfully employed as a *petuntse*. With pleasure I hear that an ingenious gentleman has found a true kaolin and petuntse in Devonshire and Cornwall, and that he has lately established a manufactory of genuine porcelain. It is to be hoped that he may succeed in the introduction of this very elegant and useful manufactory: and

DXLVIII. PORCELAIN of Mr. REAUMUR. Mr. Reaumur having made many experiments to discover the nature of the materials which enter into the composition of the oriental porcelain, and having ascertained that all porcelain is an intermediate substance betwixt an earth and glass, very ingeniously thought of reducing glass ready made to the state of porcelain, by undoing the vitrification, or partly unvitrifying it: hence this kind of ware has been called *porcelain unvitrified*. Mr. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky color, semi-transparent, so hard as to strike fire with steel, unfusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine-bottles are made, succeeds best. The glass-vessel which is to be converted into porcelain is to be enclosed in a baked earthen case or segger. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glass vessel will be found transformed into such a matter as we have described.

This kind of porcelain has not a very white color, particularly on its surface; but for some purposes it may be useful, especially for chemical vessels. Mr. Reaumur has not explained how this transformation is effected. The cause of it probably is, that the vitriolic acid of the gypsum quits its basis of calcareous earth, and unites with the alkaline salt and saline earth of the glass, with which it forms a kind of salt or selenites different from the calcareous selenites, by the interposition of which matter the glass acquires the qualities of porcelain. (y)

and although many and great difficulties, besides the discovery of proper materials, must occur in the execution of that work, yet these are not insuperable.

(y) Mr. Reaumur says, that glass thus rendered opaque, white, unfusible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every essential quality of porcelain it is equal to any, and even superior in the property of sustaining alterations of heat and cold.

The character given by Mr. Reaumur of this porcelain induced Dr. Lewis (who had also observed the changes produced upon glass-retorts exposed to violent heat in a sand-bath) to make further experiments on this matter, an account of which he has published in the *Philosophical Commerce of Arts*, a work which we much wish to see prosecuted in the same able and useful manner in which it has been begun.

From Dr. Lewis's experiments we find the following results. 1. *Green glass* cemented with white sand received no change in a heat below ignition. In a low red-

heat the change proceeded exceeding slowly; and in a *strong red-heat*, approaching to whiteness, the thickest pieces of glass bottles were thoroughly converted in the space of three hours. 2. The glass suffered the following *progression of changes* by continued heat: First, its surface became blue, its transparency was diminished, and a yellowish hue was observable when it was held between the eye and the light. Afterwards it was changed a little way on both sides into a white substance, externally still bluish; and as this change advanced still further and further within the glass, the color of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were disposed nearly parallel to one another, and transverse to the thickness of the piece: by degrees the glass became throughout white and fibrous, the external bluishness at the same time going off, and being succeeded by a dull whitish or dun color: by a still longer continuance in the fire the fibres were changed gradually from the external to the internal part, and converted

## DXLIX. PORPHYRY. (z)

DL. POTASH. See ALKALI (FIXED).

DLI. POTTERY. The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by

verted into grains; and the texture then was not unlike that of common porcelain. The grains, at first fine and somewhat glossy, appeared afterwards larger and duller, and at length the substance of the glass became porous and friable, like a mass of white sand slightly cohering. 3. Concerning the *qualities* of the converted glass Dr. Lewis observes, that the whiteness of the internal part was not inferior to that of porcelain, but that its surface was the least beautiful, that the thick pieces were quite opaque, and that several thin pieces were semi-transparent: that while it remained in a fibrous state, its hardness became greater than that of glass, or of the common kinds of porcelain; it was capable of sustaining sudden changes of heat and cold better than any porcelain; and in a moderate white heat, it was fusible into a substance not fibrous, but vitreous and smooth, like white enamel: that when its texture had become coarsely granulated, it was now much softer and unfusible: and, lastly, that when some coarsely granulated, unfusible pieces which, with the continuance of a moderate heat, would have become porous and friable, were suddenly exposed to an intense fire, they were rendered remarkably more compact than before; the solidity of some of them being superior to that of any other ware. 4. No differences appeared in the internal color, hardness, texture, or the regular succession of changes, from the use of *different cementing substances*; though in external appearances the differences were considerable. All the pieces which had been surrounded with charcoal or with soot were externally of a deep black color, which did not disappear by exposure to a strong fire during an hour, with free access of air. Colored clays and sands communicated different shades of a brown color; and white earths gave whitish, greyish, or brownish tinges. White sand, calcined flints, and gypsum, gave in general the greatest whiteness, and tobacco-pipe clay the greatest glossiness and brightness. 5. Glasses composed of earths without alkaline salt, glass of lead, flint-glass, crown-glass, looking-glass plates, a glass prepared with

calcined flints and a fixed alkaline salt, and even green glass which had been fused together with a ninth part of alkaline salt, suffered none of the above alterations by cementation. Green bottle-glass and common window-glass were most susceptible of these alterations. 6. The changes produced by cementation could not proceed from any absorption of matter from the cementing substance; because no increase of weight was given, and because the same changes were produced upon a piece of glass merely by heat, without any cementing substance. The *real cause of these changes* seems to be, that a part of the alkaline salt of the glass, to which the vitrified state of the earth is owing, exudes by heat, and is imbibed by the surrounding matters, as appears from the concretion observable in these matters after a long cementation. Those glasses only are susceptible of change which contain but a small quantity of alkaline salt; because no more of this salt being contained than is necessary to give a vitrified state to the earth, any exudation of it must in some measure unvitriify the glass, and approximate it more and more to the state of the earth of which it was formed. Perhaps also the first degree of change may partly depend on an alteration produced by the heat in the glass itself considered as a compound, or in the nature of its alkaline ingredients, which we know are liable, by exposure to fire, to lose something of their saline nature, and to be partly changed to earths.

(z) PORPHYRY is a compound stone consisting of Jasper, in which particles of felspar, and sometimes of mica and basalt, are interspersed. Its colors are green, red, black, brown, or dark grey, varying according to the color of the jasper which is the basis of this compound stone, and of the quantity and colors of the interspersed particles. Porphyry is generally fusible by fire. Its fusibility is probably owing to the metallic matter with which the jasper is tinged, and to the basalt or other fusible particles intermixed. The surface of this stone is generally covered with a whitish crust.

chemists,



chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. We must, however, acknowledge, that although chemists have most interest to procure good crucibles and other earthen vessels, this art has been left almost entirely to the potter. Mr. Pott is the first and the only chemist who has attended to this object. Besides many experiments related in his *Lithogæognosia*, from which much instruction may be received relating to the perfection of chemical vessels, he has written a treatise expressly on this subject, in which he gives many compositions for crucibles, the chief of which shall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths; because these earths are capable of being kneaded, of easily receiving any form, and of acquiring much solidity and hardness by exposure to fire. But clays differ much in the effects produced upon them by fire. Some clays, which are of the purest kind, resist the most violent fire without receiving any other change than a considerable hardness; but still they are not rendered so hard and compact as other clays. A second kind of clays by exposure to violent heat acquires a hardness equal to that of flints, and a texture compact and glossy, like that of good porcelain; but they are nevertheless unfusible by the most violent heat. These qualities are occasioned by some fusible materials being mixed with them, as sand, chalk, gypsum, or ferruginous earth, which are in too small a quantity to effect a complete, but only a beginning or partial fusion. Lastly, a third kind of clays is first hardened by fire, and afterwards is completely fused. This last kind of clay evidently contains the largest quantity of the fusible matters above-mentioned.

From the properties of these three principal clays we may conclude, that from clays alone three principal kinds of pottery may be produced. With the first kind of clay, pots or crucibles may be formed capable of sustaining the most violent fire without fusion, of containing melted metals, and even hard glasses not too fluid; but which, from want of sufficient compactness, are incapable of containing during a long time in fusion very fusible substances, such as nitre, glass of lead, glasses containing much arsenic, &c. by which substances their pores are pervaded. These clays are employed advantageously for the formation of large pots or crucibles used in glass-houses for containing hard glass, as bottle-glass.

With clays of the second kind may be made crucibles and other potteries, commonly called stone-ware. Potteries made with these earths, when sufficiently baked, are very sonorous, so hard as to strike fire with steel, capable of containing all liquids, of which the former kind, from their porosity, are incapable, and even resist the action of nitre, glass of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardness and density, which prevents their sudden expansion and contraction, by the hasty application of heat and cold, makes them liable to break in all operations where they are suddenly exposed to heat or to cold, as, for instance, in a furnace through which a strong current of air passes. If this kind of pottery had not this inconvenience, it would be the best and most perfect for the purposes of ordinary life and chemistry. Notwithstanding this inconvenience, this is the only pottery that is applicable in many occasions, and then all possible care must be taken

to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

Lastly, with fusible clays may be made many kinds of vessels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but slightly baked; hence its texture is coarse and porous. Some utensils are made of this pottery without glazing, as foot-stoves, &c. But in general they are covered with a glazing, without which water or other liquids would pass through their pores. Some of this pottery, which is finished with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called *DELF WARE*, *whicb see*. Other coarser potteries of this kind are glazed with glass of lead mixed with metallic calxes, or fusible colored earths, from which they receive various colors. This is the ordinary pottery.

Lastly, a fine kind of pottery is made of white clays, or of such as whiten in the fire, the surface of which is vitrified by throwing into the furnace, when the ware is sufficiently baked, some common salt and salt-petre. This pottery is called *English-ware*, because the first and best was made in England. True, white English ware is not without merit; it is white, fine, well baked, and has some small degree of transparency when thin; so that it is intermediate betwixt porcelain and common stone-ware, and may therefore be called a semi-porcelain. (a)

Some of these potteries can sustain a sudden application of heat and of cold, sufficiently well for the uses of a kitchen, and are therefore called *fire-ware*: but these are always the coarsest, least baked, and the glazing of which is the softest. They also do not last long when much used; for it is a chimera to suppose, as some persons do, that pottery may be made capable of sustaining fire like a metal vessel. We are certain that the best of this kind which are employed for this purpose, break as soon as they are put upon the fire. They do not break so as to separate in pieces, or even to let liquors pass through them; but many small cracks are formed; which we may be assured of by the crackling heard upon their being first set on the fire, by the many cracks which may be perceived in their glazing, and by their ceasing to ring when struck, after they have been once heated. Each time that these vessels are set

(a) I have never seen any English stone-ware that had the semi-transparency and whiteness mentioned by the author. As the English stone-ware is composed of tobacco-pipe clay and ground flints, both which substances are perfectly unfusible, singly, or jointly, it cannot possess any degree of transparency. The use of the flints is to give strength to the ware, so that it shall preserve its form during the baking: whereas vessels made of clay alone, although unfusible by fire, and capable of acquiring, by having been exposed to an intense heat, the hardness of the best porcelain; while they are hot, are soft, sink by their weight, so as to lose the form given to them. This stone-ware

is glazed in the manner mentioned by the author, but by means of common salt only, without any mixture of nitre. This glazing has not the beauty or smoothness of good vitreous glazings. Another kind of stone-ware, called *Queen's ware*, is made in England, and lately much used. It is composed of the same materials as the former, but with a less proportion of flints, as it is to be exposed to a less violent heat than the former ware; the vitreous glazing with which it is covered not being capable of sustaining such heat. Its color is less white than that of the former, having a yellowish tinge; but the ware is preferred on account of the smoothness of its glazing and neatness of its forms.

on the fire, many small imperceptible cracks are formed in them, which by frequent use become so numerous, that the vessel may be broken by the least force. Thus all the difference betwixt the potteries which are intended to be used on the fire and the good stone-ware which is not intended for that purpose is, that this latter kind may be broken at once, when heated and cooled carelessly, whereas the former is broken by degrees. Nevertheless, this fire-ware is useful, as it can serve for a short time.

We shall not describe the operation of making pottery, because we have already spoken of it under the articles *DELF-WARE* and *PORCELAIN*, from which the common ware only differs, with regard to its manufacture, in its greater simplicity. We shall here add some observations concerning chemical vessels, as retorts, muffles, and crucibles.

All the operations where great heat is employed require vessels of baked earth; because these alone can sustain at once the action of violent fire and of chemical solvents. Vessels made of good baked clay eminently possess these two qualities, and are the best which can be employed in chemistry; but as they have the inconvenience of breaking by sudden application of heat and cold, and as many operations do not require vessels so dense, mixtures of earth have been used, of which crucibles are made, capable of being made suddenly red-hot, and suddenly cooled without breaking, and sufficiently dense to contain metals and other matters in fusion during a long time. The best crucibles of this kind are brought from Hesse, in Germany. These crucibles are made with a good refractory clay, mixed, according to Mr. Pott, with two parts of sand, of a middling fineness, from which the finest part has been sifted. The mixture of sand with clay produces two good effects; the first, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it sustains during its drying; and, secondly, to prevent its acquiring too great closeness and compactness of texture by being baked. Thus we obtain crucibles moderately dense, capable of containing metals and other things in fusion, and infinitely less subject to break by heat and cold than those made of pure clay.

The particles of the sand mixed with clay in this composition for crucibles ought to be rather of a moderate size than very fine; because, as Mr. Pott remarks, the former renders the crucibles much less apt to crack than the latter. In the second place, that chemist forbids the use of sand, flints, or other earths of that kind in the composition of crucibles intended to contain glasses or vitrifying matters a long time in fusion; because these vitreous matters act upon sand, flints, and all those called vitrifiable earths; by which means these crucibles are soon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of sand are procured by substituting to the sand a good baked clay in gross powder. In this manner are made the pots which contain the vitrifiable materials in glass-house furnaces, some of which resist the continued fires employed there during three weeks or a month (*b*). The quantity of burnt clay

(*b*) The pots used in glass-houses frequently sustain a constant fire during several months, and sometimes even a year. They become gradually more and more thin, the glass or flux contained probably dissolving them thus slowly.

in the composition for crucibles varies in proportion to the nature of the crude clay, from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the stronger, more tenacious, and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are composed on the same principles. They are made of clay mixed with broken butter-pots, which are a stone-ware made in Normandy and Piccardy. These crucibles resist admirably well sudden heat and cold, and they would be excellent if the crude clay which enters into their composition was capable of resisting a violent fire: but this clay being mixed with martial and pyritous matters swells in the fire, and begins to melt. Besides, these crucibles owe their good quality of not breaking by sudden application of heat and cold to their little density, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may, from what has been said, perceive the difficulty, perhaps the impossibility, of making perfect crucibles. Mr. Pott has made so many experiments on this subject, that he seems to have exhausted it. The basis of all his compositions was clay; but this he mixed in different proportions with metallic calxes, calcined bones, calcareous stones, talks, amianthus, asbestos, pounce-stones, tripoli, and many others, from none of which did he obtain a perfect composition, as may be seen from his Dissertation: hence we conclude, that we must have in our laboratories crucibles of different kinds suitable to the several operations; Paris crucibles, when the matters contained are not too fluid, and the fire is not too strong; Hessian crucibles, when similar matters are to be exposed to a violent heat; and crucibles of baked clay for vitrescent matters and penetrating fluxes.

Crucibles may possibly be made better than any hitherto known, and of more extensive use. The essential point is to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the sand must be washed. This must be mixed with two or three parts of the same clay baked and pounded grossly; and of this mixture or paste crucibles must be formed in moulds, and baked in a very strong fire. As retorts and cucurbits are designed for the distillation of liquors generally very corrosive and penetrating, they ought to be made of stone-ware. (c)

(c) To what the Author of the Dictionary has said concerning *crucibles*, I shall add some farther extracts from Mr. Pott's Dissertation above-quoted.

1. Crucibles made of fat clays are more apt to crack, when suddenly exposed to heat, than those made of lean or meagre clays. *Meagre clays* are those in which a considerable quantity of sand is mixed with the pure argillaceous earth, and *fat clays* are those which contain but a small proportion of sand. 2. Some crucibles become porous by long exposure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external surfaces, which may be done by moist-

ening these with oil of tartar, or by strewing upon them when wetted with water, powdered glass of borax. These glazings are not capable of containing glass of lead. 3. Crucibles made of burnt clay *grossly powdered*, together with unburnt clay, were much less liable to crack by heat than crucibles made of the same materials, but in which the burnt clay was *finely powdered*, or, than crucibles made entirely of unburnt clay. 4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of grossly powdered burnt clay, and three drams of calcined vitriol, are capable of retaining melted metals, but

**DLII. P O W D E R.** This name is given in general to all dry substances when divided into very small parts. As in many chemical operations the substances employed must be necessarily reduced into very fine powder, different methods have been invented for this purpose according to the nature of the substances to be powdered. See *DIVISION*..

In pharmacy many remedies are in form of powder, and which are called *powders*; but these do not belong to our subject. Some chemical preparations and mixtures are known by the name of powder, as the *powder of Algaroth*, *gun-powder*, *fulminating powder*, of all which we shall treat.

**DLIII. P O W D E R of A L G A R O T H.** This preparation, called also *emetic powder* or *mercurius vitæ*, is a kind of calx of regulus of antimony, separated from the butter of antimony by water alone.

The marine acid, which cannot be united to the regulus of antimony but by particular processes and when it is highly concentrated, as we see from the operation of butter of antimony, is much disposed to separate from it; and accordingly is separated, at least the greatest part of it is separated, by dilution with a sufficient quantity of water. When therefore water is poured upon butter of antimony, the same thing happens as when water is mixed with the saline combination of the vitriolic acid with mercury; that is, the greatest part

but are pervaded by glass of lead. The following composition is as good or better than the preceding. Seven ounces of unburnt clay, fourteen ounces of grossly powdered burnt clay, and one dram of calx of vitriol. These crucibles may be rendered more capable of containing glass of lead, by lining their internal surfaces, before they are baked, with unburnt clay diluted with water. They may be further strengthened by making them thicker than is usually done, or by covering their external surfaces with some unburnt clay, which is called *arming* them. 4. The composition of which crucibles the most capable of containing glass of lead were made, was eighteen parts of grossly powdered burnt clay, as much unburnt clay, and one part of fusible spar. These crucibles must not, however, be exposed too suddenly to a violent heat. 5. Crucibles capable of containing very well glass of lead were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. These required to be armed. 6. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal surface of a Hessian crucible, rendered it capable of containing glass of lead during a long time. 7. One part of clay and two parts of Spanish chalk made good crucibles. The substance called Spanish chalk is not a calcareous earth, but appears to be a

steatites. 8. Two parts of Spanish chalk and one part of powdered tobacco-pipes made a good composition for lining common crucibles. 9. Eight parts of Spanish chalk, as much burnt clay, and one part of litharge, made solid crucibles. 10. Crucibles made of black-lead are fitter than Hessian crucibles for the melting of metals; but they are so porous, that fused salts pass entirely through them. They are more tenacious than Hessian crucibles, are not so apt to burst in pieces, and are more durable. 11. Crucibles placed with their bottoms upwards are less apt to be cracked during the baking than when placed differently. 12. The paste of which crucibles are made ought not to be too moist, else when dried and baked they will not be sufficiently compact: hence they ought not to be so moist as to be capable of being worked on a potter's lathe, but they must be formed in brass or wooden moulds. See *Mr. Pott's Dissertation on Chemical Vessels*.

Mr. Scheffer says, that the best crucibles cannot easily contain metals dissolved by sulphur, in the operation of parting by means of sulphur. See *PARTING*. He says, that they may be made much more durable and solid, by steeping them a few days in linseed oil, and strewing powdered borax upon them before they are dried. *Mém. Suev.* xiv. 1752.

of the regulus of antimony is separated from the marine acid, or at least it retains too little of this acid to continue soluble, but is separated in form of a white precipitate, while the rest of the regulus remains dissolved in water by means of the superabundant acid.

The acid liquor in which the precipitate or powder of algaroth is formed has been called by the ancient chemists, very improperly, the philosophical spirit of vitriol; for it does not contain an atom of vitriolic acid. We must not believe that it is pure marine acid, for it retains, as we have said, a small portion of the regulus of antimony; the proof of which is that this earth may be precipitated and rendered sensible by an alkali.

The earth thus precipitated by water from butter of antimony, after it has been frequently and perfectly washed with much distilled water, is called *powder of Algaroth*, from the name of a physician who used it as a remedy. This preparation of antimony given in doses from a grain to three or four grains is a powerful emetic and purgative; but unconstant in its effects, and even dangerous, as all the preparations of antimony are which are not in a saline state.

Most chemists believe that the powder of algaroth retains a part of the acid of butter of antimony, and attribute its effects partly to this acid. When this powder has not been perfectly washed, it does indeed retain some acid, which may give it a degree of causticity. But we are not certain that all the acid cannot be washed from it by much water, or by being boiled in a large quantity of water. Mr. Beaumé pretends that it is very possible; but however well washed this powder may have been, it still preserves an emetic quality, nearly as great as that of glass of antimony; which is not surprising. For if we suppose that this antimonial earth was absolutely deprived of acid, yet as it was combined with the marine acid, which does not deprive metals of all their phlogiston, it retains enough of this principle to possess an emetic quality, as in general all antimonial calxes do when not perfectly dephlogisticated.

Lemery says, that the powder of algaroth cannot be dissolved either by spirit of nitre or by ordinary aqua regia, but that it is soluble by a mixture of the spirit of nitre, of sea-salt, and of vitriol. As that chemist is very accurate, what he says is probably true. I shall nevertheless observe, that I have dissolved this powder perfectly and entirely with cream of tartar, in the usual manner of dissolving glass of antimony in the preparation of emetic tartar, and thus obtained a neutral crystallizable salt. This experiment induces me to believe, that powder of algaroth may be used advantageously for the preparation of an emetic tartar, of more certain and more uniform quality than that which is prepared from glass of antimony. *See the reasons for this opinion, at the word TARTAR (EMETIC).* *See also the articles ANTIMONY, BUTTER of ANTIMONY, and ELZOAR MINERAL.*

DLIV. P O W D E R. (G U N). Gun-powder is an intimate mixture of 75 parts of purified nitre, of 15 parts of charcoal, and of 9 parts of sulphur. The quickness of the kindling of this composition, and the violence of the explosion occasioned by this sudden inflammation, is universally known. The theory of the detonation of gun-powder is exactly the same as that of the detonation of nitre with any other inflammable matter. Therefore we refer to the article DETONATION of NITRE for this theory.

The

The goodness and force of gun-powder depend upon two essential points, first, that all the contained nitre be inflamed; and secondly, that this inflammation be made in the shortest time possible, and almost in an instant.

The proper quantities of sulphur and of charcoal in the composition of nitre procure the inflammation of all the contained nitre; and the quickness and force of this inflammation depends upon the intimacy and accuracy of the mixture of the component parts of the powder.

From experience we find that the proportions of the several ingredients mentioned above are the best, that is, that they are sufficient for the detonation of the whole nitre. A larger quantity of sulphur and charcoal would lessen the force of the powder; because altho' these substances be inflammable, yet the force of their inflammation is nothing in comparison of detonating nitre. Care must be taken that no uninflamable matters be mixed with the gun-powder, and therefore the nitre must be very well purified, and freed from the common salt mixed with it, which is not inflammable; and also from the salts with earthy bases, which are contained in the mother water of nitre, and which have the bad quality of attracting powerfully the moisture of the air, as this quality renders these salts capable of spoiling powder, in other respects good.

The quickness of the inflammation of gun-powder depends not only on the purity of the nitre and on the just proportion of the ingredients, but also on the accurate distribution, and the intimate mixture of these. The reason of this is very evident. As the salt-petre cannot be inflamed but by means of immediate contact with some inflammable matter, we may easily perceive that the finer the particles are of the salt-petre, and also of the sulphur and charcoal, and the more intimately these three ingredients are mixed, the greater is the number of the points of contact, since the surface of each of the ingredients is thereby encreased; and hence the quicker the detonation must be. Accordingly all the operations in the making of gun-powder are to compleat these two intentions.

For this purpose, nitre of the third boiling, and well purified, is chosen, and also very pure sulphur and good charcoal. The charcoal of light woods is generally employed; but Mr. Beaumé, who has very minutely and accurately examined this matter, affirms from experience, that the charcoals of heavy and hard woods, if they have been well made, are as fit for the purpose. These three ingredients are mixed in the proportions above-mentioned, and a very fine division and intimate mixture are made of them, by pounding them together, during twelve hours, in a wooden mortar, and with a wooden pestle. This mixture must be carefully moistened from time to time with some water, to prevent the matters when too dry from being raised and dissipated by this long trituration, and to prevent the mixture from kindling by the heat occasioned by the repeated strokes of the pestle. In large works, a mill is employed for this trituration, in which wooden mortars are disposed in rows, and in each of which a pestle is moved by the arbor of a wheel turned by water, as in paper mills.

When the trituration is finished, the powder is made. Nothing then remains to be done but to dry it very slowly, but compleatly. The powder is in this state composed of very fine parts, which are therefore liable to moisten in the

air, to adhere to any thing, to soil the fingers and the inside of fire-arms, into which also it does not easily slide. These inconveniencies are remedied by reducing it to small smooth grains, larger for cannons, and smaller for muskets.

The operations by which the powder is reduced into grains are very simple, and well imagined. For this purpose, it is placed to a certain thickness upon sieves, the holes of which are of a proper size; upon this stratum of powder a thick piece of wood is placed horizontally, and presses upon the surface of the powder. All this apparatus is to be agitated horizontally in several directions. The weight of the piece of wood forces the powder to pass through the holes of the sieve, and to form itself into molecules of the size of the holes. The powder is by this method granulated, but it is not rendered smooth. In its rough state it is used for artillery; but for small arms it must be smoothed, and this is effected by an operation as simple as the preceding.

For this purpose a hollow cylinder or cask is mounted upon an axis, which is to be turned by a wheel. This cask is to be filled half full of the powder to be smoothed, and it is to be turned six hours. The friction occasioned by this motion of the parts of the powder against each other is sufficient to smooth their surfaces. The granulation and smoothing of the gun-powder cannot be performed without a part of it being reduced to a fine powder, which is to be separated from the rest by a searce, and to be afterwards granulated. Those who require more particular information concerning this manufacture, or other arts and trades, may consult the *Dictionnaire portatif des arts & des metiers*. See the articles ACID (NITROUS); NITRE; DETONATION of NITRE; SULPHUR; COAL. (d)

DLV. POWDER of the CHARTREUX. See KERMES.

DLVI. POWDER (FULMINATING). This powder is a mixture of three parts of nitre, two parts of the dry alkali of tartar, and one part of sulphur. It is called fulminating, because when it is put upon a gentle fire, in an iron spoon, and slowly heated, it detonates with astonishing violence and noise as soon as it receives the proper heat.

The most remarkable circumstances in this experiment are, that this powder does not require to be forcibly confined, as gun-powder does, to make a great

(d) Mr. Beaumé analysed a pound of the gun-powder made for the French ordnance. By boiling it in water he extracted 12 ounces of salt petre; and by exposing the residuum to a heat just sufficient for the slow combustion of the sulphur, he found that it contained two ounces of sulphur and two ounces of charcoal.

Some persons, misled by an experiment of Dr. Hales, which shews that burning sulphur does not generate elastic air, but destroys the elasticity of common air, have imagined that the sulphur was an unnecessary and even hurtful ingredient of gun-powder. Mr. Beaumé, having made experiments on that subject, found that by addition of the sulphur, the force of gun-powder was nearly doubled.

The use of sulphur, as an ingredient in gun-powder, seems to be not to encrease the explosion immediately by its own combustion, but to accelerate the combustion of the other ingredients, which it does by its property of being much more easily inflammable than the charcoal. The charcoal not only concurs with the sulphur in supplying the inflammable matter which causes the detonation of the nitre, but also considerably adds to the explosive power of the detonating nitre, by the quantity of elastic vapor expelled during its combustion. Concerning the whole explosive force of gun-powder, see a Note subjoined to the article DETONATION of NITRE.

explosion,



explosion, and also that heat must be applied slowly; for the fulmination is less strong when the powder is hastily heated; and although a single gros (c) of this powder is sufficient, when heat is slowly applied, to make a noise as considerable as that of a cannon, and to produce an explosion dangerous to bystanders; yet a much larger quantity may be thrown upon lighted coals without danger, and even without explosion, because the nitre does then only gently detonate, as it does when it is alkalisied by charcoal.

The explanation of these singular effects is deducible from the theory of the detonation of nitre. The explosion produced by nitre, when inflamed with any combustible matter, is so much stronger as the quantity inflamed at once is larger, so that it is the strongest possible when all its parts kindle at once, and instantaneously: but this happens in the experiment of fulminating powder. When it is very slowly heated, it is first liquefied: a kind of liver of sulphur is formed by the combination of the alkali with the sulphur which enters into the composition of this powder; the phlogiston of the sulphur is almost entirely disengaged, and reduced into a vapor which penetrates the mass on all sides, and is equally distributed betwixt the parts of the nitre, which is then also fused. Lastly, when the heat is strong enough to kindle any part of the powder when brought to this state, all the others kindle also; both because, by having been slowly heated, they have nearly the same degree of heat, and also because they are all disposed in the most advantageous manner to inflammation. They therefore all kindle at the same time; and this instantaneous explosion strikes the surrounding air with such violence and rapidity, that this fluid has not time to give way to the sudden percussive, and consequently resists as much the fulmination of this powder, as the chamber of a gun resists the fulmination of gun-powder. Hence fulminating powder does not require to be closely confined, as gun-powder does, to make a much more considerable noise.

This circumstance also is peculiar to fulminating powder, that some instants before its explosion, a light blue flame appears upon its surface; which is nothing else than the phlogistic vapors beginning to kindle. No more fire or flame is perceptible during its fulmination: this proceeds from the quickness of the explosion, and the violence of the commotion of the air, by which the flame is extinguished and suffocated as soon as it is formed, and before it can be perceived. Hence also fulminating powder does not generally kindle the combustible bodies in contact with it, because the time of its inflammation is too short.

This powder differs in these two last phenomena from gun-powder, but they are common to it with fulminating gold. If we were certain that *nitrous sulphur* can subsist ready formed uninflamed, these effects would induce us to believe that it subsists already combined in fulminating powder and in fulminating gold, some time before their explosion, as Mr. Beaumé thinks. We cannot be certain of this, unless we could obtain nitrous sulphur single and uninflamed, as we can vitriolic sulphur and phosphorus. See ACID (NITROUS), NITRE, DETONATION of NITRE, LIVER of SULPHUR, GOLD (FULMINATING), POWDER (GUN), and SULPHUR.

(c) A gros is 72 grains.

## DLVII. PRECIPITATION, and PRECIPITATES.

Precipitation is one of the most general and important operations of chemistry. The term *precipitation*, in its most extensive sense, is applicable to all chemical decompositions made by an intermediate substance, that is, to all operations in which two bodies are disunited, by employing a third body which has the property of uniting with one of these, and thereby of separating the other. Hence we see that every precipitation is effected by means of the affinity of a precipitant, much stronger than that of the precipitate with the substance from which it is separated. This is the third case of affinity; when three substances act upon each other. See AFFINITY.

This surprising property that certain substances possess of separating others strictly united, is the true efficient cause of many chemical decompositions which could never have been performed by other means. Thus, for instance, we should never have known the acid of sea salt, sedative salt, and many other very important substances in chemistry, without the assistance of some acids more powerful than these, and capable of separating them from the bases to which they are united.

Although all these decompositions essentially belong to precipitation, yet use has confined this term to those operations only in which the substance becomes palpable when it is separated, and consequently falls by its gravity to the lower part of the vessel in which the operation is made. From this fall of the separated substance the operation has been called *precipitation*; and the substance separated, and collected at the bottom of the vessel, has been called *precipitate*.

We shall not say any thing here concerning the cause of precipitation, because our knowledge is not yet sufficiently extensive to enable us to affirm any thing upon the subject. An hypothesis relating to it may be found under the article GRAVITY. In this article we shall only mention the principal phenomena of precipitations, and the most essential properties of several precipitates.

Precipitation is never occasioned but in fluid matters; and as bodies may be rendered fluid either by fire or by water, two kinds of precipitations may be distinguished, one by the humid way, and the other by the dry way. In the first class ought to be ranged all decompositions of salts with earthy or metallic bases, which salts must be dissolved in water when their bases are to be separated from their acids by proper intermediate substances. The second class includes the separations of metals and of other solid and fusible matters from each other, which are effected by fusion and mixture with the separating substances. These two kinds of precipitation do not essentially differ: but many real differences distinguish the separated substances, or all those to which the general name of precipitate is given. This name has been given very improperly to several preparations which are not precipitates. Such are the *red precipitate*, *precipitate per se*, and some others. And amongst the preparations which may properly be called by this name, because they are substances separated from other substances by intermediate bodies, many do essentially differ from others, and ought therefore to be distinguished by different names.

When

When a body is decomposed by means of an intermediate substance, and a precipitate is formed by this decomposition, this precipitation can be effected only by the intermediate substance uniting with one of the component matters of that body; and consequently a new compound is always formed in these operations. Sometimes the separated matter, being no longer soluble, becomes sensible, and falls as a precipitate, while the new compound remains dissolved. In other instances, the separated substance remains dissolved, while the new combination, not being soluble, is precipitated. This depends on the nature of the substances which act one upon another in these operations; but we may easily perceive that the precipitates of the former kind are simple, and those of the latter are compound.

Some modern chemists consider these simple precipitates only as true precipitates, or which ought to be so called. Nevertheless, we must acknowledge that precipitates of the second kind have all the requisites to entitle them to the name of precipitate; and no inconvenience attends the giving to them that name, provided they are distinguished from the former kind by the denomination of *compound precipitates*.

Earths and metals, when separated from acids by means of alkalis or other metals, are simple precipitates, and when separated from acids by other acids, are compound precipitates. For instance, calcareous earth united with nitrous and marine acids may be separated from these by the vitriolic acid: and if this separation is effected by pouring vitriolic acid into a solution of nitre or of marine salt with calcareous basis, the liquors which were before clear will by this addition of vitriolic acid be rendered turbid and milky, and a sediment or white precipitate will soon be formed at the bottom of the liquor. This precipitate is nothing else than the calcareous earth which was united with the nitrous or marine acids, and which being separated from these acids by the vitriolic acid, unites with this latter and forms a new compound, a selenites, the greatest part of which, not being capable of remaining dissolved in the liquor, is precipitated. See SELENITES.

In the same manner, when vitriolic acid or any salt containing it is mixed with a solution of silver, of lead, or of mercury by the nitrous acid, a precipitate is soon formed, which is a combination of the metal with the vitriolic acid. See VITRIOLS.

The same thing may be said of the corneous metals, which are combinations of these metals with marine acid, by which they have been separated from nitrous acid. See LUNA CORNEA, and PLUMBUM CORNEUM.

All the precipitates above-mentioned are really new combinations of the precipitated substance with the precipitating acid; and which only separate from the liquor, and appear as precipitates, because they are not very soluble, and the liquor contains too little water to keep them suspended. This may be proved by adding a sufficient quantity of water, by which this kind of precipitates will be entirely dissolved. Nevertheless this circumstance does not prevent their being precipitates, when they are actually made by precipitation. For amongst the precipitates considered as simple, and to which many chemists would confine the name of precipitate, perhaps there is not one really simple. Modern chemists have observed, that all precipitates in general draw along with them a greater or less quantity of some other substances during  
the

the precipitation. They either retain a part of the substance with which they were united before precipitation, or a part of the precipitant, and frequently even a certain quantity of each of these matters. This depends on the nature of the bodies which act upon one another, on their proportions, and on concomitant circumstances. If any precipitates can be considered as pure and simple, certainly a metal precipitated from an acid by another metal may, as, for instance, silver and mercury separated from the nitrous acid by copper, or copper separated from acids by iron; because the precipitated metal resumes its natural color, lustre, and metallic properties. Nevertheless, when we subject these metallic precipitates to accurate trials, we discover that they are alloyed with a small quantity of the precipitating metal. In general, precipitates and the different circumstances of precipitation have been hitherto but superficially examined. It is a subject no less important than new, which deserves attention, and is replete with many discoveries.

After these explanations which we thought necessary concerning precipitation and precipitates in general, we proceed to treat of the principal chemical preparations called precipitates; because these which are not called precipitates, although they really be so, are treated of under other articles.

### MERCURIAL PRECIPITATES.

DLVIII. PRECIPITATE (WHITE). This is mercury separated from nitrous acid by marine acid, with which it then unites. White precipitate is made by pouring a solution of common salt in distilled water into a solution of mercury in nitrous acid, till no more precipitate falls. When the sediment is collected at bottom, the supernatant liquor is to be decanted, and the precipitate is to be washed several times with distilled water, and then dried.

This precipitate of mercury is one of those called compound. It is a combination of mercury with the acid of common salt; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only separated from the nitrous acid by means of the combination it forms with the marine acid. In this precipitation, then, the phenomena are similar to those which happen in the formation of luna cornea and plumbum corneum.

1. White precipitate may be made by pure marine acid. 2. When it is made by common salt, or other salt containing marine acid, two decompositions happen, and two new combinations are formed. The nitrous acid which was originally united with the mercury combines with the substance that was united with the marine acid, and forms a new nitrous salt, which remains dissolved in the liquor. When common salt is employed, cubic nitre is formed. If marine salt with an earthy basis is used, the liquor after the precipitation, contains a nitre with earthy basis. Upon this subject *see the article AFFINITY*. 3. All the mercury, although entirely separated from nitrous acid and united with marine acid, is not precipitated in the present occasion, because it is reduced to a saline compound essentially soluble in water; and consequently the liquor contains as much of it as it can dissolve, and another part of it is dissolved by the water employed to wash it. Similar events happen also in the precipitation of silver and of lead by marine acid. Accordingly, if an alkali be added to clear the liquor decanted from these precipitates, or even to the water employed to wash them, another precipitate will be formed; but this latter

latter is of a different nature, and is simple in comparison of the former, since it does not contain any acid combined directly with the metallic substances, or, at least, much less of the acid.

Lemeri gives another process for making a white precipitate, which consists in dissolving four ounces of sal ammoniac in a pound of water; to which is to be added an equal quantity of corrosive sublimate; all which could not be entirely dissolved alone in that quantity of water, but may by means of the sal ammoniac. See *SUBLIMATE (CORROSIVE), and TINCTURE of MERCURY*. Into this solution liquid fixed alkali is to be added, till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by several chemists; but it ought not to be confounded with the white precipitate formed by adding marine acid or common salt to a solution of mercury in nitrous acid; for they are evidently very different.

We may remark, that the color of this precipitate of Lemeri is influenced by the sal ammoniac; for although this precipitate be very white, the precipitate formed by adding fixed alkali to a solution of corrosive sublimate in water is brick-colored. The whiteness of the former precipitate then proceeds from the great quantity of marine acid, and even of the volatile alkali of the sal ammoniac, which affect this precipitation. This proves, that precipitates reputed simple are not so; and that they draw along with them part of the substances to which they were united, and of the precipitating substances. Great differences may be observed in this respect amongst precipitates in general, according to the quantity and proportions of substances which concur to the precipitation.

**DLIX. PRECIPITATE (YELLOW).** As chemists have given many different forms to mercury, to adapt it to medicinal uses and to chemical processes; so they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations which in fact are not precipitates. These are chiefly denominated from their colors, without adding any epithet to shew that they are mercurial. Thus *white precipitate*, *yellow precipitate*, *red precipitate*, &c. are preparations of mercury. Yellow precipitate is mercury dissolved by vitriolic acid, from which it is afterwards separated by addition of water alone; it is then in form of a yellow powder: but as this precipitate is better known by the name of *TURBITH MINERAL*, we shall treat of it under that article.

**DLX. PRECIPITATES (BLACK and ROSE-COLORED).** Lemeri, who mentions many precipitates of mercury of different colors, says, that if a solution of mercury in spirit of nitre be precipitated by urine, instead of a solution of common salt, a rose-colored precipitate of mercury will be formed; and that if afterwards some fixed or volatile alkali be added to the liquor from which the rose-colored precipitate has been formed, another precipitate which is black will be obtained.

Much common salt being contained in urine occasions the rose colored precipitate, which is essentially the same as the white precipitate obtained by pure sea-salt or marine acid. The redness of its color probably proceeds from some reddish earthy or saline earthy matter contained in urine, which it draws along with it.

The blackness of the precipitate obtained afterwards by adding alkali proceeds from the oily and phlogistic parts of the urine, which are added superabundantly to the mercury, and which always blacken white metals, as silver, lead, bismuth, these metals being susceptible of receiving inflammable matter superabundantly, when they are exposed to vapors of sulphur, of liver of sulphur, or when they are precipitated by this latter substance. See LIVER of SULPHUR.

DLXI. PRECIPITATE PER SE. This preparation of mercury is very improperly called a precipitate; because it is not separated from one substance by means of another substance, as all true precipitates are, but is only mercury reduced to a red powder by a kind of calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glass matrafs, the neck of which is very long, and the opening of a capillary size. This matrafs, the belly of which ought not to be entirely full of mercury, is to be placed in a sand-bath, and heated till the bottom of the vessel containing the sand be red-hot. This heat is to be continued during two or three months. The mercury gradually loses its lustre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the surface of the mercury, or adheres to the sides of the vessel. The operation may be shortened by using a greater number of matrasses, all which may be placed in the same bath. When enough of this red powder is obtained, it is to be collected and separated from the remaining fluid mercury. This is called *precipitate per se*, or *by itself*, or *red precipitated mercury without addition*.

This preparation of mercury we have received from the alchemists, who spared no pains nor labor to change mercury and to fix it. They received great hopes from the change of color, the want of fluidity, and the diminution of volatility which the mercury suffers by this operation. Although the mercury is much disguised by these changes, yet it is not essentially altered, because it may be reduced to fluid mercury by heat without addition. We cannot precisely explain the phenomena of this operation. Different opinions are formed concerning them. Mr. Baron conjectures, that they are caused by the union which mercury contracts by means of its being much divided with the saline particles contained in air. We see indeed from turbith mineral and red precipitate, that mercury is disposed to take the form and qualities of the precipitate per se, by an union with a small quantity of saline substance. Mr. Beaumé thinks, on the contrary, that the mercury is truly calcined, that it loses part of its phlogiston; and that, when it is exposed to heat, it is again reduced to its metallic state by the addition of the inflammable principle which passes through the containing vessels, and again combines with it. This opinion is not improbable; but more experiments and researches are wanting to decide concerning it. I should be, nevertheless, sufficiently disposed to believe, that a part of the inflammable principle contained in fluid mercury is superabundant to it, slightly adherent, and may be easily lost and recovered.

DLXII. PRECIPITATE (RED). If a solution of mercury in nitrous acid be reduced to dryness by evaporation, and the mercurial nitre thence formed be put into an open matrafs set in a sand-bath, with a fire gradually

gradually encreasing, the nitrous acid will disengage itself from the mercury, and evaporate in a red vapor. While the acid evaporates, the saline mercurial mass loses its original whiteness, becomes yellow, then orange, and lastly red.

This red matter, when separated from the matrix, (which must be broken for that purpose) and pulverised in a glass mortar, is the *red precipitate*, as it is improperly called; it not being a precipitate, but a mercurial nitre from which the greatest part of the acid is expelled by the fire, without the application of any intermediate substance. The red color of this preparation is caused by the great division of the molecules; for, from the example of the precipitate per se, and of several true mercurial precipitates, which also are red, we learn that this is the color assumed by mercury when it is not fluid, when its parts are much divided, and when it has not a superabundant quantity of phlogiston.

Notwithstanding the calcination which mercurial nitre sustains in this operation, all its nitrous acid is not expelled. The mercury still retains a quantity of acid equal to the ninth part of its weight, as Mr. Lemeris observes. This preparation is therefore corrosive, and only used externally. Several authors propose to render it milder by burning spirit of wine two or three times over it. It is then called *arcantum corallinum*, and has been given by some physicians internally. If it be indeed rendered milder by this inflammation of spirit of wine, the effect must be produced by a partial reduction of the mercury, occasioned by some phlogiston which it receives from the spirit of wine; but the internal use of this precipitate is abolished, because the effects of other preparations are more uniform and certain.

Red precipitate is much less volatile than crude mercury. Nevertheless, by a strong fire in close vessels it may be sublimed entirely, and the sublimate has the same color and other qualities as the precipitate. As nitrous acid is a very powerful agent to deprive bodies in general, and particularly metallic substances, of part of their phlogiston; and as red precipitate has all the appearance of a mercury partly deprived of its inflammable principle; I have endeavored to calcine it further by leaving it exposed a long time to fire, and by dissolving it many times in fresh nitrous acid. For this purpose I digested during four days some red precipitate with a strong heat, which I then dissolved in more nitrous acid, afterwards restored it to the state of red precipitate, and then calcined it again during four days. Eight times I repeated these calcinations and solutions: but when I examined my mercury, it appeared to be just the same as it was after the first solution and calcination. This determined me to relinquish the experiment. It proves, that if the nitrous acid does deprive the mercury of any of its phlogiston, the quantity of this principle is very small which it thus detaches, and is only that which is but little adherent and superabundant. It also proves, that nitrous acid takes as much phlogiston from the mercury the first time as it can; and that therefore any attempts to dephlogistate it perfectly would be unsuccessful by this, or probably by any other method, since this seems to be the most effectual.

Lemeris observes, that many authors have believed that the color of red precipitate might be much heightened by thrice cohobating and distilling the white mass above-mentioned with spirit of nitre; and he affirms, that this effect

is not produced by these operations. This experiment is similar to that I have mentioned, but is less capable of changing the mercury, because it is not calcined after each distillation. I have also remarked, that red precipitate is easily soluble, and produces heat, but no effervescence, with new nitrous acid. Lemerî observed the same phenomenon with vitriolic acid.

**DLXIII. PRECIPITATE (GREEN); and PRECIPITATE (BLACK), or VIOLET-COLORED MERCURY.** Some authors, particularly Lemerî, give processes for other preparations of mercury, which have been employed as remedies, and which are improperly called *precipitates*. Such is green precipitate, which is a mixture of four parts of mercury and one part of copper, dissolved separately in the nitrous acid, and treated as in the process for making red precipitate; afterwards, partly dissolved a second time by being digested with vinegar; and, lastly, reduced by evaporation to a dry consistence. Such also is the preparation called by Lemerî *violet mercury*, or *black mercurial panacea*, or *black precipitate*, which is an artificial cinnabar overcharged with sulphur, mixed with sal ammoniac, and prepared by a very long and laborious process: but as these preparations have been made only for the use of medicine, and have fallen into disrepute, we shall not say any more of them, excepting that they are singular mixtures, accompanied with many unforeseen appearances, which could not be explained without further examination and particular dissertations. See the article *MERCURY* for the medicinal virtues of all the mercurial preparations called *precipitates*.

**DLXIV. PRECIPITATE of GOLD by TIN, or PURPLE POWDER of CASSIUS.** This precipitate of gold may be made by several methods: but which of these is the best, has not yet been decided. The cause of this uncertainty is, that the preparation requires delicate management, and is uncertain in its result, the beauty of the color seeming to depend on some small circumstances not yet discovered; for we find that the color of the powder obtained frequently varies, notwithstanding the processes seem to have been the same. I have tried several methods. The following is what has best succeeded with me, and is nearly the same as that described by Mr. Gellert in his *Metallurgic Chemistry*.

Make an aqua regia with two parts of spirit of nitre and one part of spirit of salt; dilute this acid with an equal quantity of distilled water; add to it a small piece of Malacca tin, and let it be dissolved without heat. If the weather be cold, the time employed in this solution will be long; but this is rather an advantage than an injury. When this piece of tin is entirely dissolved, add another, and let it be dissolved in the same manner; continue to add more pieces of tin, one at a time, till the liquor has acquired a yellow color, and almost ceases to act upon the tin; then decant the liquor from the remaining piece of metal.

Also dissolve gold of 24 karats in an aqua regia composed of three parts of spirit of nitre, and one part of spirit of salt. This solution may be accelerated by the heat of a sand-bath.

Dilute the solution of tin in a hundred times its quantity of distilled water. Try your solutions in the following manner: Take a small quantity of the diluted solution of tin; divide it into two parts; to one of which add a known quantity



quantity of distilled water: to each of these portions of the solution of tin add a drop of the solution of gold, by which they will acquire a red purple color: observe which of the colors of the two solutions is the finest, and keep to that degree of dilution for the rest of the solution of tin: to the solution of tin thus diluted add such a quantity of the solution of gold, that there shall be in the mixture two parts of the former metal to one of the latter: stir well the mixture (which ought to be made in a large glass vessel) with a glass rod. The whole will acquire the color of red wine, and a sediment will gradually be deposited of the same color, while the liquor will become clear. Then pour into this clear liquor some drops of the solution of tin, and observe if any more gold is precipitated: when the liquor is very clear, decant it gently from the sediment, which is to be well washed with pure distilled water. This is precipitate of gold, or the purple powder discovered by Cassius. It is a valuable preparation, because it is the only one known capable of giving a red purple or crimson color to glass, enamel, and porcelain. When it is to be used, it must be well mixed, and ground with a fusible glass, as Venice glass, and this mixture is to be exposed to the degree of heat necessary for melting the glass. If a colored glass or artificial ruby be required to be made, so large a quantity of glass is to be added to the mixture that the gold shall not destroy its transparency: but for enamel painting, a smaller quantity of glass is required, that the color may be intense. The particular proportions cannot be ascertained, because the intensity of the color given by the gold is very variable.

We have already remarked, that this preparation is subject to varieties; and that by the same process it is sometimes more and sometimes less beautiful. Sometimes we can obtain only a precipitate of a black violet color; at other times we can obtain scarcely any color, without being able to discover the reason of these differences. We know, however, many essential circumstances concerning the success of the operation. We are certain, that little or no purple precipitate will be formed when the tin has been quickly dissolved, and with heat and effervescence. To understand the reason of this, we must recollect the following principles.

First, the gold is really precipitated in this experiment; for the purple powder may be reduced to gold. Besides, we know that this metal, when much divided and united with some saline parts, or perhaps even with a superabundant quantity of phlogiston, has always a reddish-purple or violet color.

Secondly, the gold is here precipitated only by means of the tin; because this latter metal has a stronger affinity than the former with the acids of aqua regia; and although it already is united with the same acids, it yet seizes those superabundantly that keep the gold dissolved, which it therefore precipitates. This proposition is proved by observing, that nothing else is added to the solution of gold in the preparation of the purple powder, than tin, aqua regia, and water; but as no quantity of aqua regia and water can occasion this precipitate, the tin therefore is the substance which does occasion it. Besides, gold may be formed into a purple precipitate by adding a piece of tin to a solution of gold in aqua regia. If a question be asked, Why, when we employ a solution of tin, that is, tin united with so much acid that it remains dissolved in much water, this tin should nevertheless seize upon the acids which keep the gold dissolved? the reply is, That tin is capable of charging itself with a

larger quantity of acid than is necessary to dissolve it; and also, that when its solution is diluted in a large quantity of water, more acid is required to keep the metal dissolved: for when a great deal of water is added to a clear solution of tin, the liquor will become turbid, and the tin will be precipitated. We cannot then be surprized that the tin, which in this dilute solution is on the point of precipitating before the solution of gold is mixed with it, and which then has scarcely a sufficient quantity of acid to keep it dissolved, should, when that mixture is made, seize the acids of the solution of gold.

Thirdly, we know that metals are capable of being dissolved in acids by means of their phlogiston. We know also that acids, and particularly the nitrous, take from the imperfect metals a part of their phlogiston during the solution of these metals, and that this loss of phlogiston sustained by metals is so much more considerable as the solution is made with more activity, quickness, and heat. Tin is more subject to lose its phlogiston than any other metal; hence it cannot continue suspended in the nitrous acid, which takes so much of its phlogiston from it, that it is soon reduced to a white calx: although the marine acid, a large quantity of which is in the solution of tin employed for the preparation of the purple powder of Cassius, considerably moderates the action of the nitrous acid, and prevents so compleat a dephlogistication as is occasioned by pure nitrous acid; nevertheless, when this solution is performed with too much activity, the tin is too much calcined, part of it is often precipitated in form of a white calx, and the remaining part which is dissolved contains so little phlogiston, that the acids of the solution of gold cannot act properly upon it: hence such a solution of tin is unfit for the preparation of the purple precipitate of Cassius, and it frequently is incapable of forming it: hence we see the reason why the success of the operation depends so much on the slowness with which the tin is dissolved.

The solution of tin must be diluted in much water, else a fine color will not be produced. The reason of this is, that the tin is so much more capable of precipitating the gold, as by the dilution of the acids with which it is united, it is more disposed to fall down spontaneously. Accordingly, a certain quantity of tin is always precipitated along with the gold, which appears in form of a white calx.

The solution of tin in aqua regia is not the only substance with which a purple powder of gold may be made. We have already seen, that a small piece of tin put in a dilute solution of gold forms a purple precipitate. Orschal mentions this and several other very curious experiments on the same matter, in his little Treatise called *Sol sine Velle*. For instance, we there find that the smoking liquor of Libavius makes also a purple precipitate. I have found that tin dissolved in marine acid likewise makes it. The same chemist further says, that a solution of mercury in spirit of nitre mixed with a solution of gold produces a more beautiful precipitate than tin; that fulminating gold, that gold itself when much divided, like the powder scraped off a piece of gold by pounce-stone, being mixed and melted with vitreous matters, make a red glass. These facts prove, that this color is natural to gold, whenever it is very much divided.

This purple powder appears to have been a secret and a novelty in the time of Orschal; as he says that he learnt it from Cassius himself. Several contem-

porary chemists believed, that the gold was decomposed in this operation, and vitrified in the red glass which received its color from it: but Orichal, less disposed to the marvellous, because he was more intelligent, remarks, that the gold is not decomposed, and only is less easily reducible than when under another form; which is a true explanation. See *TIN and GOLD*. (f)

**DLXV. PRINCIPLES.** This name is given to substances obtained from compound bodies, when their analysis or chemical decomposition is made.

Philosophers and chemists have long ago discovered, that almost all natural bodies are capable of being reduced to a greater or less number of other bodies less compounded, similar to each other, and almost the same, of whatever nature the body was from which they were separated. This important observation has induced a belief, that the innumerable productions of nature were only the results of the combination of a few more simple substances, the different proportions and arrangements of which formed the diversity of all compound bodies. These last bodies retain the name of *compounds*; and the more simple substances, from the union of which these compounds result, are called *principles*: but as the number and nature of the principles of bodies can only be discovered and ascertained by many laborious chemical experiments, and as in these latter times only, chemistry has been properly cultivated as a part of natural philosophy, ancient philosophers could only give vague conjectures concerning the number and nature of the principles of bodies. Accord-

(f) Long cylindrical pieces of glass, called *Jewels glass*, are commonly sold, and much used by manufacturers of glass-toys. This glass, though perfectly colorless, yet when it is exposed to the heat and flame of a lamp, acquires a beautiful ruby color, exactly similar to that of pure glass melted with powder of Cassius. As no other known substance but gold gives that color to glass, we may presume that this glass contains some of that metal; in which case, the gold appears to be vitrified, and more changed than in any other known preparation of it. Kunkel says, that having occasion frequently to make this ruby glass, he had sometimes observed the glass, when taken out of the crucible, instead of being colored as usual, to appear colorless as crystal, and to acquire a ruby color by exposure to the flame of a lamp.

Dr. Lewis observes, that though a purple or a ruby color may easily, by the methods published, be applied upon glass or enamel, and introduced into the mass by fusion, the way of equally diffusing such a color thro' a quantity of fluid glass is still a secret. That author says, that he has made several

trials of this kind, in one of which the glass was uniformly tinged of a ruby color; and in the others various colors, as yellow, red, and brown, appeared, and were unequally diffused: but he had not discovered the circumstances upon which these differences depend. Orichal, in his *Treatise Sol sine Veste*, gives a process by which he obtained a fine ruby glass. He directs, that the powder of Cassius should be ground with six times its quantity of Venice glass finely powdered; and that this mixture should be well mingled with a frit consisting of equal parts of borax, nitre, and fixed alkaline salt, and four times as much calcined flint as of any of the salts: but he does not mention the proportion of the powder of Cassius to the frit, nor in what manner the fusion is to be performed.

Kunkel says, that one part of the powder of Cassius is sufficient to give a ruby color to twelve hundred and eighty parts of glass.

Dr. Franklin observes, that gold-leaf placed betwixt two plates of glass being exposed to an electrical shock, stained the contiguous glass with red spots, which were sunk into the body of the glass.

ingly, in each school of philosophy different opinions prevailed concerning these principles, some of them admitting one only, and others more: some asserting that water was the principle of all things; some contending for earth, and others for fire. We do not intend to discuss all these opinions; but shall only observe, that almost all the ancient philosophers have been mistaken from a want of a sufficient number of chemical experiments and observations.

The chemists of the middle ages, that is to say, about the time of Paracelsus, had very confused notions concerning this matter. They admitted five principles of bodies, which they called *mercury* or *spirit*, *phlegm* or *water*, *sulphur* or *oil*, *salt*, and *earth*. By *mercury* they probably meant whatever is volatile, and which in the analysis of bodies is capable of affecting the taste and smell. This conjecture is confirmed by the name *spirit*, which they also gave to the same principle. Their *phlegm* comprehends all the watery unflammable products obtained in the analysis of bodies. By *sulphur* they meant not only sulphureous matters and common sulphur, but also any oils, and all the inflammable matters obtained in the decomposition of bodies. All saline matters obtained in these analyses were comprehended under the general name *salt*. Lastly, they applied the word *earth* to the fixed matters which remain after the analysis of bodies. We shall afterwards see that some of these principles, which are called the principles of Paracelsus, are simpler than others; hence obscurity and confusion have been introduced into the opinions formed concerning principles in general.

Beccher, perceiving this inconveniency in the principles of Paracelsus, attempted to reduce their number, and to give more precise notions of them. He established only two general principles of all bodies, namely, water and earth: but as he could not explain the properties of all compounds from these two principles, he admitted three kinds of earths, which he considered as equally simple and elementary. The first he called *vitriifiable earth*, which, according to him, is the principle of the fixity, of the solidity, and of the hardness of bodies. He called his second earth *inflammable earth*, which he supposes to be the principle of inflammability of all inflammable bodies. Lastly, the third earth of Beccher is called *mercurial earth*. He considered this earth as forming with the two others metallic substances, and he also admitted it as a principle in the composition of other bodies, particularly of the marine acid. This chemist gave the name *earth* to these three last mentioned principles, because he considered them as being of a dry nature, and as differing essentially from water, which he considered as a principle essentially humid.

The theory of Beccher concerning principles is very profound, and may be considered as the source of the most important discoveries of modern chemistry: but we must confess, that had not the illustrious Stahl commented upon this theory, illustrated and extended it, we might have received no benefit from it.

This excellent chemist easily shewed, that water and vitriifiable earth enter as elements into the composition of many bodies; for these two principles are sensible, and all the experiments of chemists shew their existence in most compounds: but the other two principles of Beccher, namely, his mercurial earth and his inflammable earth, have not, even yet, been exposed to our senses, single and pure; and therefore all the sagacity and genius of Stahl were required to demonstrate the existence and properties of this inflammable earth, which

which we now call *phlogiston*, or *inflammable principle*, and which is nothing else than the very substance of fire when rendered a principle of bodies. See *PHLOGISTON*.

The existence of the mercurial earth is not satisfactorily demonstrated either in the works of Beccher or of Stahl. We have nothing but inferences and presumptive proofs of its existence. See upon this subject *METALS and METALLISATION*.

That earth, water, and fire enter into the composition of bodies as principles, may be considered now as demonstrated by Beccher and Stahl. The experiments of many philosophers and chemists, particularly Boyle and Hales, have shewn that air also enters into the composition of many bodies as a principle, and even in very large quantities. Thus if we add this fourth principle to the three others above-mentioned, we shall find to our surprize, that we now admit as principles of all compounds the four elements, fire, air, water, earth, which Aristotle taught were such, long before the knowledge of chemistry was sufficient to establish this truth.

In whatever manner bodies are decomposed, we always obtain these substances. They are the utmost limits of chemical analysis. As we cannot by any means decompose these further, we consider them as simple substances, (although perhaps they may not be so) and are therefore called *primary principles* or *elements*. See *ELEMENTS, AIR, EARTH, FIRE, WATER, PHLOGISTON*.

When we decompose most bodies, we cannot nearly reduce them to their elements or primary principles by a first analysis, especially when they are much compounded. We obtain from them substances more simple only, but still compounded of other principles, for a reduction to which another analysis is requisite. As these substances, although compounded of a certain number of principles, do themselves the office of principles in the composition of bodies less simple than themselves, they have been called *principle principles*. The principle principles have so much better title to this name, as they subsist in their state after they have been separated from a body, characterised by peculiar properties, unalterable but by a new analysis, and capable of reproducing by their union a compound entirely like that from which they were originally separated. Most chemical agents, as acids and alkalis, are of this kind.

In the analysis of very compound bodies, principle principles of different degrees of simplicity, or rather such as are capable of being reduced to others more and more simple, may be thus obtained successively, by first, second, and third analyses: hence several kinds of principle principles of different degrees of simplicity, and which consequently are, by a true gradation, principles of one another, have been distinguished. Modern chemists distinguish them by names which mark their order of composition. Thus substances which cannot be further decomposed, and which are considered as simple, are called *primary principles*. *Secondary principles* are those which result immediately from the union of primary principles. *Principles of the third order* are those which are composed of secondary principles, and so on.

We may also with propriety distinguish the principles of bodies by the names of *proximate principles* and *remote principles*, by applying the former name to the principle principles obtained directly from a body by a first analysis, and

by applying the latter name to the principles obtained by a further decomposition of these proximate principles.

These distinctions will be rendered more intelligible by an example; for the subject of which let us chuse a neutral salt, such as nitre. We have demonstrated that this salt is a compound of the acid, called *nitrous*, and of the fixed vegetable alkali, combined and saturated together. By a first analysis then of nitre we shall obtain this acid and this alkali, which are therefore the proximate principles of nitre. But neither nitrous acid nor fixed alkali are simple substances. By a further analysis of each of these, they may be decomposed into water, earth, fire, or inflammable principle. This acid and this alkali must then be considered as *principle principles*. But as the substances obtained from them are unalterable, and cannot be further decomposed, they must be considered as *primary principles*; the acid and the alkali of the nitre are then immediately composed of primary principles, and they themselves are consequently principle principles, or secondary principles, or *principles of the second order*. In this example the water, earth, and fire, are the remote principles of the nitre.

Altho' these several denominations and distinctions of principles more or less simple be just and useful for the illustration of many important points in the theory of chemistry, this science is not however sufficiently advanced to enable us to determine the number and kinds of principle principles of different orders, and especially of the higher orders. We know but a few, which, we have strong reasons to believe, belong to the second order; such, for example, are saline substances, and the more simple acids and alkalis, but we are not entirely certain of this, because we have not been able to produce any of these substances from the union of the primary principles, in such a manner, that no doubt can be admitted. See the articles COMBINATION, ANALYSIS, DECOMPOSITION.

#### DLXVI. PUMICE-STONE. (g)

DLXVII. PURIFICATION. By purification is meant any chemical operation by which substances required to be obtained pure and single are separated from other heterogeneous matters with which they happen to be mixed.

As the several chemical agents and other matters are generally more or less confounded, and even combined with substances of different natures; and as we require in many accurate experiments that they should be very pure, we must therefore apply the proper methods to give them the necessary degree of purity.

But these methods differ very much according to the nature of the substance to be purified. They must be appropriated to their peculiar natures, and also to the nature of the substances to be separated. For the several purifications, we are obliged to employ almost all the operations of chemistry. Hence many operations are only true purifications, altho' they are not so called. For instance, all the second distillations and sublimations called *refinements*, are nothing else than purifications. They are employed for the purification of volatile sub-

(g) PUMICE-STONE is a light, porous, spongy stone, resembling the scoria of furnaces. Its colors are white, yellowish, brown, or black. It is found near volcanos, and is believed to be a substance reduced to a burnt or semi-burnt state by subterranean fire. Wallerius conjectures that it is the silica of fossil acids thus changed by fire. Pumice-stone is fusible by intense heat.

stances

stances from others that are fixed, or less volatile. In this class may be ranged the rectifications of oils, of volatile spirits and salts, of ardent spirits, and even of mineral acids; and the sublimations of sulphur, of arsenic, of cinabar, of salt of amber, of flowers of benjamin, and of sal ammoniac. See RECTIFICATION and SUBLIMATION. Also the repeated solutions, filtrations, evaporations, and crystallizations of neutral salts are only means of purifying them. See CRYSTALLIZATION, and SALT (NEUTRAL). Several calcinations, and particularly those of fixed alkalis, are intended merely to purify them, by depriving them of a greasy matter or superabundant inflammable principle. See CALCINATION, and ALKALI (FIXED). Many solutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their allay. Lastly, the repeated fusions of metallic substances, the smelting of ores, cupellations, and refining, are true purifications of metallic matters. Amongst all these operations, but a very few are called *purifications*: such as the purification of silver by nitre, of gold by antimony, of both which we shall now treat.

#### DLXVIII. PURIFICATION of SILVER by NITRE.

The silver to be purified by nitre is to be first granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potash, and a little common glass, all in powder. This mixture is to be put into a good crucible, two-thirds of which only must be full. This crucible is to be covered with a smaller crucible inverted, and luted to the former, and in the bottom of which a small hole has been made. The crucibles thus disposed are to be placed in a furnace, capable of drawing air sufficiently to make the fire intense enough only to melt the silver. Then charcoal is to be put into the furnace to such a height, that only the top of the inverted crucible shall be uncovered. The coal is then to be kindled, and the vessels to be made moderately red: a hot coal ought to be put upon the small hole in the bottom of the inverted crucible. If a shining light be observed round this coal, and a slight hissing noise be at the same time heard, we may know that the operation proceeds well. The fire must be sustained at the same degree, till these appearances cease; when it must be encreased so that the silver be well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the silver will be found at the bottom covered with a green alkaline scoria. If the metal be not sufficiently pure and ductile, the operation must be again repeated.

This operation is founded on a property which nitre has of effectually calcining all imperfect metals, by burning their phlogiston; and also upon a property of calcined metals, by which they cannot be united with others in their metallic state. This being established, when silver allayed with copper or other imperfect metals is to be treated with nitre, this salt quickly calcines these imperfect metals by detonating with their inflammable principle; and they are no sooner calcined, than they are rendered incapable of remaining united with the silver. These metallic calxes being also specifically lighter, rise above the silver, where they meet the alkalinized nitre and potash, with both which they form a scoria. The silver being capable of resisting the action of the nitre, is thus disengaged from its allay, is fused, and collected at the bottom of the crucible.



As the purification of silver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with swelling and effervescence, the crucibles must not be too firmly closed, otherwise this effervescence might break them, and some of the contained matter might be lost: therefore a small hole is left in the upper crucible, which serves as a cover to the other; besides, the empty space left in the vessels thus disposed, allows the matter contained to swell a little without loss.

This small hole is also very useful to shew the proper degree of fire during the operation, as has been said. The light and the hissing noise, which may be perceived when a coal is applied, are occasioned by part of the nitre which is raised up undecomposed during the detonation. When these effects are too considerable, and that a sensible hissing may be heard at the small hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In that case the fire must be lessened, otherwise much of the nitre would be carried off, and together with it, some part of the silver, which would be lost. And even, notwithstanding all the precautions that can be used, this operation can scarcely be performed without some loss of the silver. Small grains of silver are always to be seen in the upper crucible, and about the small hole in it. This inconvenience prevents the operation from being employed to determine the value of silver, for which purpose *cupellation* is therefore used.

The purification of silver by nitre, has nevertheless its peculiar advantages in some circumstances. It is more quick and expeditious than *cupellation*, and the loss of silver is not considerable, when all the proper attentions are observed. See SILVER, NITRE, and DETONATION of NITRE.

DLXIX. PURIFICATION of GOLD by ANTIMONY. To purify gold from its allays by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of crude antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left some minutes in fusion: after which, when the mixture is well fused, and so hot that its surface sparkles, it is quickly to be poured into an iron cone, previously heated and greased. By striking the cone against the ground, the descent of the regulus will be assisted; and when the cone is cold, it is to be inverted, and the matter taken out. This matter consists of two substances; the upper one of which is composed of the sulphur of the antimony united with the metals with which the gold was allayed, and the lower is the gold united with a quantity of the regulus of antimony proportionable to the quantity of metals which have been separated from the gold, and which are now united with the sulphur of the antimony. This regulus of gold may be separated from the sulphurated metals which cover it; and will be found to be so much less yellow, that is, mixed with so much more regulus of antimony, as the gold was more allayed.

As a single fusion is not generally sufficient to disengage the gold from all its allay, it ought to be fused again in the same manner, and with the same quantity of antimony, and even a third time, if the gold was much allayed. It is fusible with less fire the second and third time than the first, from the regulus of antimony which is united with it.

This.



This first part of the purification of gold by antimony is founded on a property of sulphur, by which it is incapable of uniting with gold, and is therefore disposed to unite with all other metallic substances excepting platina and zinc, and also upon this property of sulphur, that it has less affinity with regulus of antimony than with any metallic substance with which it can unite. Hence when gold allayed with silver, copper, iron, lead, &c. is melted together with crude antimony, these latter metals unite with the sulphur of the antimony, while the reguline part, disengaged by them from its sulphur, unites with the gold. The separation of metals from gold is then really occasioned by the sulphur of the antimony. This purification of gold is consequently a kind of *dry parting*, but it succeeds better than the dry parting by sulphur alone. The reason of this difference is, that sulphur being very volatile and inflammable, is in great measure dissipated and consumed, when it is employed alone, before it can seize the metals allayed with the gold; whereas when it is already united with a metallic substance, as it is in the antimony with the reguline part, which prevents it from being quickly consumed and dissipated, it may be much more easily applied to the metallic substances allayed with gold. Notwithstanding this advantage, as a quantity of regulus of antimony is always united with the gold, proportionable to the quantity of metallic substances separated by means of the sulphur of the antimony; and as the separation of this regulus from the gold requires much time, as we shall soon see; therefore, when we would purify gold that is much allayed, suppose under 16 karats, we ought to add along with the antimony some pure sulphur, that we may have a less quantity of regulus to separate afterwards from the gold.

When these first fusions have been well made, the gold obtained is allayed with only regulus of antimony. But as this semi-metal is very volatile and very combustible, it may be separated from the gold by a sufficiently long exposure to the action of fire. For this purpose, the regulus of gold obtained by the former operation is to be put into a large crucible, and heated sufficiently to keep it in good fusion. With this heat, the antimony will be dissipated in smoke. If the heat be too strong, some of the gold will be carried off with the antimony. The operation therefore must be performed slowly; and it continues a long time, when much of the regulus of antimony is united with the gold; but it may be abridged by blowing on the surface of the metallic mass, because the application of fresh air accelerates the evaporation of all bodies, and particularly that of the regulus of antimony. When a part of the regulus is dissipated, more heat is required to keep the metal fused, and therefore the fire must be increased towards the end of the operation: besides, when only a small quantity of regulus of antimony remains, it is so covered by the gold, and protected from the action of the fire and air, that a stronger heat is necessary to evaporate it. The smoke ceases entirely towards the end of the operation, although some regulus still remains united with the gold. The purification is completed by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony. Sometimes after these operations, the gold is found to be deprived of much of its usual ductility, which however is easily restored to it by fusing it with nitre and borax.

The ancient chemists called antimony the *balneum regis*, or the *balneum solis*, and the *lupus metallorum*, from this property which it possesses, of purifying gold. The sulphur of this mineral does, indeed, seize almost all the metals with which gold can be allayed; but these metals are not destroyed, but only reduced to a sort of mineral state by the sulphur, forming the scoria, from which they may be obtained. Therefore, when the gold contained much allay of silver, the scoria is very valuable, since it contains all the silver which was united with the gold. This scoria ought to be preserved and treated like an ore of silver, and thus the metal extracted from it. See ESSAYS, and SMELTING OF ORES. See also ANTIMONY, GOLD, SULPHUR.

DLXX. PUTREFACTION. Putrefaction is an intestine motion or fermentation excited in the proximate principles of vegetables and animals, by which a decomposition and total change of the nature of these principles are produced, and an alkaline quality is given to the saline principles of the compound bodies which suffer it.

As putrefaction is a true fermentation, and even is the termination and ultimate degree of all fermentations, therefore all vegetable and animal matters which are fermentable, are also capable of putrefaction. Some matters are susceptible of putrefaction only, and not of the two previous degrees of fermentation, namely, the spirituous and the acid fermentations. These matters have either already suffered the two previous degrees of fermentation, or their principles are disposed by nature in the same manner as if they had already suffered these fermentations: most substances perfectly animalised are of this kind.

When fermentable matters of this kind contain a sufficient quantity of water, when they are exposed to a suitable degree of heat, and have all the requisite conditions for fermentation in general, they never fail to suffer putrefaction. The phenomena accompanying this last degree of fermentation are nearly the same as those of the two former degrees, excepting that they are less sensible, at least when the putrefaction proceeds slowly. But this subject has not been sufficiently attended to. Mr. Beaumé affirms, that putrefaction is not accompanied with any sensible heat. When indeed the putrefaction proceeds slowly, and the quantity of putrefying matter is but small, the heat, if any, is very little; but the most sudden and remarkable changes produced upon a body by putrefaction, are upon its color, smell, and taste. Flesh beginning to putrefy is well known to exhale very soon a penetrating fetid smell, its color to become livid and black, and its taste nauseous. Transparent liquors, as urine and broth, during putrefaction, become also turbid. As the putrefaction advances, the smell becomes more and more fetid, but it also acquires great pungency. This pungent smell of putrefying matters is very sensible in houses of office, when the weather is changing, particularly before a frost. This pungency is sometimes so considerable that it excites coughing, and draws tears from the eyes. It is caused by a large quantity of volatile alkali, which is disengaged when these substances are completely putrified.

Solid bodies, while they are putrefying, swell, become soft, lose the cohesion of their parts, and are lastly reduced to a very disgusting liquor.

From

From matters completely putrefied may be obtained by distillation volatile alkali, some liquid and some solid; pungent, fetid oil, which at first is thin, and afterwards becomes more thick; and a residuum of coal not easily reducible to ashes. Most chemists affirm that no fixed alkali is obtained from matters which have undergone a complete putrefaction; but Mr. Beaumé assures us that these matters contain fixed alkali ready formed, which may be obtained without fire. This matter requires a more particular examination; perhaps several stages of putrefaction are attended with considerable differences in this respect.

From the history of putrefaction we may see that this last degree of fermentation alters entirely the nature of substances which suffer it, whatever the qualities of their proximate principles may be. By putrefaction they lose their distinctive properties, as they are all converted into volatile alkali, fetid oil, and earth: their organization is destroyed, their vessels, fibres, cells, the very texture of the most solid parts, are changed, disjoined, and entirely resolved. All these changes are spontaneously produced upon organized bodies as soon as their vital motion ceases. As soon as vegetables and animals die, nature completes their destruction, decomposes machines now useless, reduces their materials to a similar and common state; elaborates them again, so as to fit them to pass into the organization of other beings, which also must afterwards undergo the same changes. Thus by an uninterrupted course of operations, nature incessantly renews the life of beings, which, notwithstanding the old age and deaths of individuals, is sustained in perpetual vigor and youth, as has been observed by one of our most eloquent modern philosophers.

We have already remarked that the nature and phenomena of putrefaction have been but too little examined hitherto. We shall add here, that whatever attention may be given to this subject, we shall perhaps be never able to know more than the beginnings of this operation, and even a small part only of these. In fact, putrefaction seems to be a very extensive operation, and its last stage seems in some measure out of our reach. We consider that a matter is entirely putrefied, when nothing remains but earth, or the fixed parts of it. But these coarse materials are the least part of those which compose organized bodies. The existence even of these residuums deprived of all other principles, the volatility of the saline and oily principles which are continually exhaling and dissipating during putrefaction, shew that nature is incessantly, during this operation, attenuating, subtilizing, volatilizing, and carrying off all it can of these bodies; and all the substances, thus elaborated and carried off, are removed from the reach and observation of our senses. We do not know, and probably we never shall know, what further changes they suffer, before they enter into the combination of new beings.

But if the complete theory of putrefaction be very difficult, it is also very important, as it seems to be the true key of the most essential and hidden secrets of the animal economy. In fact, as the proper substance of all the parts of the bodies of animals differs from vegetable matters, (by which all animals are mediately or immediately nourished) in this circumstance, that they are much nearer the state of putrefaction, we have reason to believe that the change of vegetable into animal matters is principally produced by a kind of fermentation, or even by a beginning, slow, and imperceptible putrefaction. In this

point, certainly, perfect *animalisation* consists; and consequently the animal economy cannot fail of being deranged; and reduced to a morbid state, whenever this animalisation, or imperceptible putrefaction, (for I do not scruple to give it that name) becomes too much or too little: which truth is well perceived by the great Boerhaave in his aphorisms concerning the diseases proceeding from spontaneous acids and alkalis.

These considerations are certainly sufficient to induce chemists and physicians to acquire all the knowledge they can on this subject. The first trials to be made in this way, and from which the greatest certainty and utility may be expected, are researches to shew what substances accelerate and retard putrefaction. Messrs. Pringle and Macbride have made the first steps, and have published the interesting experiments which they have made on this subject, which is very far from being exhausted. I know that a very able French experimental philosopher has finished a numerous set of well made experiments on this subject, which he proposes soon to publish. See FERMENTATION. (b)

(b) To the above article we make the following additions.

1. Putrefaction, as also fermentation in general, seem to consist not merely in the decomposition and transposition of the particles of the putrefying or fermenting matter, by which new combinations are produced, but also in the extrication and expulsion of some of the constituent parts of these matters. The constituent part, thus extricated and expelled by putrefaction and fermentation, is a permanently elastic vapor, or fixable air. A part of the air extracted from putrefying substances was found by Mr. Cavendish's experiments to be inflammable. See AIR, (FIXABLE). And from the experiments of Dr. Macbride, which shew that caustic alkali and quicklime may be rendered mild, or combined with air, by absorbing the elastic vapor extricated from putrefying and fermenting substances, we have reason to believe that another part of the vapor extricated from these substances is of the uninflammable kind of fixable air which combines with alkaline salts and earths. See AIR (FIXABLE) and QUICKLIME.

Dr. Hales believes that this air is the principal cause of cohesion and solidity of bodies. He remarks that air abounds much more in solid than in liquid bodies, and that solid bodies being generally denser than water, the attraction of the air of these solid bodies, in a fixed state, and its repulsion when in an elastic state, are greater than the attraction and repulsion of the lighter watery particles in a fixed and in an elastic state; and hence the particles of air are fitted to be the

principal band of union in solid bodies, than the particles of water. That Sir Isaac Newton had entertained a similar opinion, appears from the following passage in the third book of his Optics. "The particles of fluids which do not cohere too strongly, and are of such a smallness as renders them most susceptible of those agitations which keep liquors in a fluor, are most easily separated and rarefied into vapor, and, in the language of the chemists, they are volatile, rarefying with an easy heat, and condensing with cold. But those which are grosser, and so, less susceptible of agitation, or cohere by a stronger attraction, are not separated without a stronger heat, or perhaps not without fermentation. And these last are the bodies which chemists call *fixed*, and being rarified by fermentation become true permanent air; those particles receding from one another with the greatest force, and being most difficultly brought together, which upon contact cohere most strongly. And because the particles of permanent air are grosser, and arise from denser substances than those of vapors, thence it is that true air is more ponderous than vapor, and that a moist atmosphere is lighter than a dry one, quantity for quantity."

Dr. Macbride also maintains this opinion, and further endeavors to shew, that without the extrication of this air, no putrefaction can happen; and even that by absorption of its putrescent substances may be corrected and rendered sweet. Having exposed putrid matters to the vapors arising from fermenting

**DLXXI. PYRITES.** Pyrites is a mineral resembling the true ores of metals, in the substances of which it is composed, in its color or lustre,

ing mixtures, or from alkaline substances effervescing with acids, he found the putrid quality was destroyed; and hence he considers this air as powerfully antiseptic.

2. Contact of atmospherical air is said to be necessary to putrefaction; and Mr. Boyle relates that he has preserved lemons, oranges, and other fruits, from putrefaction, or other fermentation, during several years, by including them in an inexhausted receiver. Dr. Macbride found that putrefaction was accelerated by enclosing a piece of flesh in an exhausted receiver; but that another piece continued sweet, which was included in an exhausted hollow brass sphere, consisting of two hemispheres joined together. He conjectures that the cause of this difference might be, that in the latter experiment the vacuum was more perfect than in the former, as the glass receiver did not seem to exclude with sufficient accuracy the external air, and that tho' a partial vacuum may accelerate putrefaction, yet some air may be necessary to this process.

It is well known that bodies are preserved from putrefaction by covering them with wax, suet, &c. Whether is this effect produced merely by excluding external air, or also by preventing the extrication of the internal fixable air?

3. Sir John Pringle has made experiments to determine the powers of certain substances to promote or to prevent putrefaction. From these experiments he has formed the following table, shewing the relative antiseptic powers of the saline substances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to 90 degrees of Fahrenheit's thermometer, became putrid in 14 hours, and that sixty grains of sea-salt preserved a similar mixture of beef and water more than 30 hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers.

Sea-salt, or the standard  
Sal-gem

1  
1 +

Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus	2 +
Crude sal ammoniac	3
Saline mixture	3
Nitre	4 +
Salt of hartshorn	4 +
Salt of wormwood	4 +
Borax	12
Salt of amber	20
Alum	30

N. B. The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other neutral salts.

*Myrrh, aloes, assafetida, and terra Japonica,* were found to have an antiseptic power 30 times greater than the standard. *Gum ammoniacum, and sagapenum,* shewed little antiseptic power.

Of all resinous substances, *camphor* was found to resist putrefaction most powerfully. Sir John Pringle believes that its antiseptic power is 300 times greater than that of sea-salt.

*Chamomile flowers, Virginian snake-root, pepper, ginger, saffron, contrayerva root, and galls,* were found to be 12 times more antiseptic than sea-salt.

Infusions of large quantities of *mint, angelica, ground-ivy, green tea, red roses, common wormwood, mustard, and horse-radish,* and also decoctions of *poppy-heads,* were more antiseptic than sea-salt.

Decoctions of *wheat, barley, and other farinaceous grains,* checked the putrefaction by becoming sour.

*Chalk, and other absorbent powders,* accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One dram of *sea-salt* was found to preserve two drams of fresh beef in two ounces of water, above 30 hours, uncorrupted, in a heat equal to that of the human body, or above 20 hours longer than meat is preserved in water without salt; but half a dram of salt did not preserve it more than two hours longer than pure water. Twenty-five grains of

in its great weight, and, lastly, in the parts of the earth in which it is found, since it almost always accompanies ores. It is, like ores, composed of metallic substances, mineralised by sulphur or by arsenic, or by both these matters, and of an unmetallic earth intimately united with its other principles.

Notwithstanding the conformity of pyrites with ores properly so called, chemists and metallurgists distinguish the former from the latter minerals ;

of salt had little or no antiseptic quality. Twenty grains, fifteen grains, but especially ten grains only of sea-salt were found to accelerate and heighten the putrefaction of two drams of flesh. These small quantities of sea-salt did also soften the flesh more than pure water.

The same ingenious physician made experiments to discover the effects of mixing vegetable with animal matters.

Two drams of raw-beef, as much bread, and an ounce of water, being beat to the consistence of pap, and exposed to 90° of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and swell, the putrefaction had begun ; and in a few hours afterwards, the smell was offensive. Next day the putrid smell ceased, and an acid taste and smell succeeded. Fresh alimentary vegetables, as spinach, asparagus, scurvy-grass, produced similar effects as bread on flesh, but in a weaker degree. From several other experiments he found that animal substances excite the fermentation of vegetable substances, and that the latter substances correct the putrescency of the former.

By adding *saliva* to a similar mixture of flesh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the usual duration, and the acid produced at last was weaker than when no *saliva* was used.

By adding an *oily substance* to the common mixture of flesh, bread and water, a stronger fermentation was produced, which could not be moderated by the quantity of *saliva* used in the former experiment, till some *fixed alkaline salt* was added, which salt was found, without *saliva*, to stop suddenly very high fermentations.

He did not find that *small quantities* of the following salts, *sal ammoniac*, *nitre*, *vitriolated tartar*, *sal diureticus*, *salt of hartshorn*, *salt of wormwood*, were septic, as small quantities of sea-salt were.

*Sugar* was found to resist putrefaction at

first, as other salts do, and also to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables.

*Lime-water* made some small resistance to putrefaction.

*Pest wine*, *small-beer*, infusions of *bitter vegetables*, of *bark*, and the juice of *antiscorbutic plants*, retarded the fermentation of mixtures of flesh and bread. But an *unstrained decoction of bark* considerably increased that fermentation.

*Crabs-eyes* accelerated and increased the fermentation of a mixture of flesh and bread.

*Lime water* neither retarded nor hastened the fermentation of such a mixture : but when the fermentation ceased, the liquor was neither putrid nor acid, but smelt agreeably.

*Flesh pounded in a mortar* was found to ferment sooner than that which had not been bruised.

The tough inflammatory crust of *blood* was found to be most putrescent, next to which the crassamentum, or red coagulated mass, and lastly the serum.

Dr. Macbride's experiments confirm many of these above related, especially those which shew that the fermentation of vegetable substances is increased by a mixture of animal or putrescent matter ; that the putrescency of the latter is corrected by the fermentative quality of the former ; and that the putrefaction and fermentation of mixtures of animal and vegetable substances were accelerated by additions of absorbent earths and of *Peruvian bark* : He also found that altho' unburnt calcareous earths were septic, quicklime and lime-water prevented putrefaction, but that they destroyed or dissolved the texture of flesh.

The experiments of the author of the *Essai pour servir à l'Histoire de la Putrefaction* shew that metallic salts, resinous powders, extracts of bark, and opium, are very powerfully antiseptic, and that salts with earthy bases are less antiseptic than any other salts.

and they do this with propriety, because the proportion and connexion of the materials composing the pyrites differ much from those of ores.

Altho' sometimes pyrites contains more metal than some ores, yet generally it contains less metal, and a larger quantity of mineralising substances, sulphur and arsenic, and particularly of unmetallic earth. The connexion of these matters is also much stronger in pyrites than in ores, and they are accordingly much harder; so that almost every pyrites can strike sparks from steel. From this property of striking sparks from steel they have been called pyrites, which is a Greek word signifying *fire stone*. Pyrites was formerly used for fire-arms, as we now use flints; hence it was called *carabine-stone*. It is still named by some, *marcasite*. Perhaps no other kind of natural body has received so many names. Persons curious to know the other names less used than those we have mentioned, may find them in *Henckel's Pyritologia*. We think, with that celebrated chemist, that the subject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confused and inaccurate.

Pyrites differs also from ores by its forms and positions in the earth. Altho' pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly speaking, themselves form the oblong and continued masses called veins, as ores do, but they form masses sometimes greater and sometimes smaller, but are always distinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalk, marles, marbles, plasters, alabasters, slates, spars, quartz, granites, crystals, in a word, in all earths and stones. Many of them are also found in pit-coals and in other bituminous matters.

Pyrites is also distinguishable from ores by its lustre and figure, which is almost always regular and uniform, externally or internally, or both. Some ores indeed, like those of lead, many ores of silver, and some others, have regular forms, and are in some manner crystallized; but this regularity of form is not so universal, and so conspicuous in ores as in pyrites. The lustre of pyrites seems to be caused by its hardness, and the regularity of its form by the quantity of mineralising substances which it contains.

By all these marks we may easily, and without analysis, distinguish pyrites from true ores. When we see a mineral that is heavy, possessed of metallic lustre, and of any regular form, the mass of which appears evidently to be entire, that is, not to have been a fragment of another mass, and which is so hard as to be capable of striking sparks from steel, we may be assured that such a mineral is a pyrites, and not an ore.

The class of pyrites is very numerous, various, and extensive. They differ one from another in the nature and proportions of their component parts, in their forms and in their colors. The forms of these minerals are exceedingly various. No solid regular or irregular can easily be conceived that is not perfectly imitated by some kind of pyrites. They are spherical, oval, cylindrical, pyramidal, prismatic, cubic; they are solids with 5, 6, 7, 8, 9, 10, &c. sides. The surface of some is angular, and consists of many bases of small pyramids; while their substance is composed of these pyramids, the points of which all unite in the center of the mass.

Pyritous minerals differ also in their component substances. Some of them are called sulphureous, martial, cupreous, arsenical, as one or other of these substances

predominate. We must observe with Henckel, whose authority is very great in this subject, that in general all pyrites are martial, as ferruginous earth is the essential and fundamental part of every pyrites. This earth is united with an unmetalllic earth, with sulphur or arsenic, or with both these matters; in which case, the sulphur always predominates over the arsenic, as Henckel observes. He considers these as the only essential principles of pyrites, and believes that all the other matters, metallic or unmetallic, which are found in it, are only accidental; amongst which he even includes copper, although so much of it exists in some kinds of pyrites, that these are treated as ores of copper, and sometimes contain even 50lb. of copper each quintal. Many other metals, even gold and silver, are sometimes combined in pyrites; but these are less frequent, and the precious metals always in very small quantities; they are therefore justly to be considered as accidental to pyrites. The different substances composing pyrites sensibly affect its colors. Henckel distinguishes them in general into three colors, white, yellowish or a pale yellow, and yellow. He informs us, that these three colors are often so blended one with another, that they cannot be easily distinguished, unless when compared together.

The white pyrites contain most arsenic, and are similar to cobalt and other minerals abounding in arsenic. The Germans call them *mispickel* or *mispilt*. Iron and arsenic form the greatest part of this pyrites. As arsenic has the property of whitening copper, some pyritous minerals almost white, like that of Chemnitz, in Misnia, are found to contain forty pounds of copper per quintal, and which are so much whitened by the arsenic, that they are very like white pyrites. But Henckel observes, that these pyritous matters are very rare, and are never so white as the true white pyrites, which is only ferruginous and arsenical.

Yellowish pyrites is chiefly composed of sulphur and iron. Very little copper and arsenic are mixed with any pyrites of this color, and most of them contain none of these two metallic substances. This is the most common kind of pyrites: it is to be found almost every where. Its forms are chiefly round, spherical, oval, flattened, cylindrical, and it is composed internally of needles or radii, which unite in the center or in the axis of the solid.

Yellow pyrites receives its color from the copper and sulphur which enter into its composition. Its color, however, is inclined to a green, but is sufficiently yellow to distinguish it from the other two kinds of pyrites, particularly when they are compared together. To make this comparison well, the pyrites must be broken, and the internal surfaces must be placed near each other. The reason of this precaution is, that the color of minerals is altered by exposure to the air.

Persons accustomed to these minerals can easily distinguish them. The chief difficulty is to distinguish white pyrites from cobalt and other minerals, which also contain some copper and much arsenic.

Hence then we see, that arsenic is the cause of whiteness in pyrites, and is contained in every pyrites of that color; that copper is the principal cause of the yellow color of pyrites; and that every pyrites which is evidently yellow contains copper; that sulphur and iron produce a pale-yellow color, which is also produced by copper and arsenic; hence some difficulty may arise in distinguishing.



guishing pyrites by its colors. We may also observe, that sulphur and arsenic, without any other substance, form a yellow compound, as we see from the example of orpiment or yellow arsenic. Thus, although the colors of the pyrites enable us to distinguish its different kinds, and to know their nature at first sight, particularly when we have been accustomed to observe them; yet we cannot be entirely certain concerning the true nature of these minerals, and even of all minerals in general, that is, to know precisely the kinds and proportions of their component substances, but by chemical analysis and decomposition.

Besides the above-mentioned matters which compose pyrites, it also contains a considerable quantity of unmetallic earth, that is, an earth which cannot by any process be reduced to metal. Henckel, Cramer, and all those who have examined this matter, mention this earth, and prove its existence.

We ought to observe, that this earth is combined with the other principles of the pyrites, and not merely interposed betwixt its parts. It must therefore be distinguished from other earthy and stony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, since they may be separated by mechanical means, and without decomposing that mineral: but the earth of which we now treat is intimately united with the other constituent parts of the pyrites, is even a constituent part of pyrites, and essential to the existence of this mineral, and cannot be separated but by a total decomposition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, since he found from the analyses which he made, that the iron, which is the only metal existing in these pyrites, is only about  $\frac{1}{10}$ th part of the fixed substance that remains after the arsenic has been expelled by torrefaction or sublimation.

A much larger quantity of iron is in the pale-yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and sometimes fifty or sixty pounds: this is therefore called martial pyrites. It contains about  $\frac{1}{4}$  of its weight of sulphur, and the rest is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are also martial, since, as we have observed, iron is an essential part of every pyrites, has not yet been determined. They probably contain some of that earth, though perhaps less of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks that it is an earth disposed already by nature to metallization, but not sufficiently elaborated to be considered as a metallic earth. See the *articles* METALS and METALLISATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not suspect that this unmetallic earth is of the nature of the basis of alum or argillaceous earth? See ALUM and CLAY. Perhaps also this earth is different in different kinds of pyrites. The subject deserves to be well examined.

Although pyrites is not so valuable as true ores, because in general it contains less metal, and but exceedingly little of the precious metals; and because its metallic contents are so difficult to be extracted, that, excepting cupreous pyrites, which is called *pyritous copper ore*, it is not worked for the sake of the

contained metal; yet it is applied to other purposes, and furnishes us with many useful substances; for from it we obtain all our green and blue vitriols, much sulphur, arsenic, alum, and orpiment. *See the principal processes by which these substances are extracted from pyrites, under the article SMELTING of ORES.*

As every pyrites contains iron, and most of them contain also sulphur; as the pyrites most frequently found contains only these two substances with the unmetallic earth; and as iron and sulphur have a singular action upon each other, when they are well mixed together and moistened; hence many kinds of pyrites, particularly those which contain only the principles now mentioned, sustain a singular alteration, and even a total decomposition, when exposed during a certain time to the combined action of air and water. The moisture gradually penetrates them, divides and attenuates their parts; the acid of the sulphur particularly attacks the martial earth, and also the unmetallic earth, its inflammable principle is separated from it, and is dissipated. While these alterations happen, the pyrites changes its nature. The acid of the sulphur which is decomposed forms with the fixed principles of the pyrites, vitriolic, aluminous, and selenitic salts; so that a pyrites which was once a shining, compact, very hard mineral, becomes in a certain time a greyish, saline, powdery mass, the taste of which is saline, austere, and stiptic.

Lastly, if this mass be lixiviated with water, crystals of vitriol, and sometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and crystallization.

This alteration and spontaneous decomposition of pyrites is called *efflorescence* and *vitriolisation*; because the pyrites becomes covered with a saline powder; and because vitriol is always formed. This vitriolisation is more or less quickly accomplished in pyrites according to its nature. It is a kind of fermentation excited by moisture amongst the constituent parts of these minerals; and it is so violent in those which are most disposed to it, that is, in the pale-yellow pyrites, which contain chiefly sulphur and iron, that when the quantity of these is considerable, not only a sulphureous vapor and heat may be perceived, but also the whole kindles and burns intensely. The same phenomena are observable, and the same results are formed, by mixing well together and moistening a large quantity of filings of iron and powdered sulphur: which experiment Lemerier has made, to explain the causes of subterranean fires and volcanos.

We cannot doubt that, as the earth contains very large masses of pyrites of this kind, they must undergo the same changes when air and moisture penetrate the cavities containing them; and the best natural philosophers agree, that very probably this surprizing decomposition of pyrites is the cause of subterranean fires, of volcanos, and of mineral waters, vitriolic, aluminous, sulphureous, hot and cold.

No other pyrites is subject to this spontaneous decomposition, when exposed to humid air, but that which is both martial and sulphureous, that is, the pale yellow pyrites. The arsenical pyrites, or that which contains little or no sulphur, is not changed by exposure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and  
regularly

regularly shaped, is chiefly of this kind. Mr. Wallerius, in his *Mineralogy*, proposes to distinguish this kind of pyrites by the name of *marcasite*. When cut, it may be polished so well as to give a lustre almost equal to that of diamonds, but without refracting or decomposing the light; for it is perfectly opaque. It has been employed some years past in the manufacture of toys, as of buckles, necklaces, &c. and is called in commerce *marcasite*. See *WALLERIUS (MINERAL), ORES, SMELTING of ORES. (i)*

**DLXXII PYROPHORUS of HOMBERG.** The Pyrophorus is a chemical preparation, which has the singular property of kindling spontaneously when exposed to air. It was accidentally discovered by Mr. Homberg. This chemist was endeavouring to extract a limpid and flavorless oil from human ordure, which should have the property of fixing mercury (*see EXCREMENTS of ANIMALS*); and when he had mixed the substance upon which he was operating with different matters, he was much surprized, while he was taking the caput mortuum of one of these mixtures out of a retort, four or five days after it had been operated upon, to see it kindle and burn strongly as soon as it was exposed to air. He recollected that this was the residuum of a mixture of alum and human feces from which he had obtained all that he could by means of a red-heat. He repeated the process, and obtained from it the same result. When he was well assured of it, he published his discovery. Human feces were a long time believed to be essential to the operation, till the youngest son of the great Lemerai found, that honey, sugar, flour, in a word, any animal or vegetable matter, might be substituted in place of the human feces; and since that time, Mr. Lejay de Suvigny, Doctor of Physic, a person well versed in mathematical and physical sciences, has communicated to the Academy a Memoir, relating experiments made on the pyrophorus, in which he generalises the process, and gives the true theory of it. He there shews, that most vitriolic salts may be substituted for the alum; which discovery assisted him greatly in explaining the theory of the operation. This Memoir is printed in the third volume of the Collection of Memoirs by correspondents of the Academy.

(i) I do not know any sufficient reason for considering the minerals called *pyrites* as a distinct class of substances from ores. They have indeed no mark by which they can certainly and constantly be distinguished from these. The hardness or property of striking ignited sparks from steel is not common to all the substances generally called pyrites; for we find some of these enumerated by mineralogists which have not that property. Wallerius even mentions a pyrites which contains no iron, although that metal is thought by Henckel to be essential to pyrites. The distinction of pyrites from

ores has been chiefly introduced by miners; because the greatest part of the former minerals contain so little metal, and so much of the mineralising substances, sulphur, or arsenic, that they are seldom smelted. Nevertheless, some kinds of pyrites are found which contain so much copper, that they are smelted with great profit. Accordingly, some later mineralogists consider the cupreous yellow pyrites as an ore of copper, the pale-yellow martial pyrites as an ore of iron, and the white arsenical pyrites as an ore of arsenic. See *ORES of COPPER, IRON, and of ARSENIC.*

Although

Although alum is not absolutely necessary for the preparation of the pyrophorus, yet it is one of the vitriolic salts which succeeds best. The following process is very good for this preparation.

Let three parts of alum and one part of sugar be mixed together. This mixture must be dried in an iron shovel over a moderate fire, till it be almost reduced to a blackish powder of coal, during which it must be stirred with an iron spatula. Any large masses must be bruised into powder, and then it must be put in a glass matrafs, the mouth of which is rather strait than wide, and seven or eight inches long. This matrafs is to be placed in a crucible, or other earthen vessel, large enough to contain the belly of the matrafs, with about a space equal to the thickness of a finger all round it. This space is to be filled with sand, so that the matrafs shall not touch the earthen vessel: the apparatus is then to be put in a furnace, and the whole to be made red-hot: the fire must be gradually applied, that any oily or fuliginous matter may be expelled. After which, when the matrafs is made red-hot, sulphureous vapors exhale: This degree of heat is to be continued till a truly sulphureous flame, which appears at the end of the operation, has continued nearly a quarter of an hour: the fire is then to be extinguished, and the matrafs to cool without taking it out of the crucible; and when it ceases to be red-hot, it must be stopped with a cork. Before the matrafs is perfectly cold, it must be taken out of the crucible, and the powder it contains must be poured into a very dry glass phial, which must be well closed with a glass stopper. If we would preserve this pyrophorus a long time, the bottle containing it must be opened as seldom as is possible. Sometimes it kindles while it is poured into the glass phial, but it may be then extinguished by closing the phial expeditiously.

When half a dram of this pyrophorus is put on a piece of paper and exposed to air, it quickly kindles, becomes red like burning coals, emits a strongly sulphureous vapor, and burns the paper or other combustible body which supports it.

This preparation has hitherto been used only to entertain curious persons with a sight truly surprizing, of a substance which contains within itself a principle of fire capable of burning spontaneously, and which being more inflammable than any other substance known, kindles without contact of an ignited matter. The phenomena which it exhibits confirm Stahl's theory concerning the composition of sulphur, and give a striking proof of the almost incredible force and activity with which the vitriolic acid, when highly concentrated, but not perfectly combined, unites with the moisture of the air.

In the first place, we cannot doubt that sulphur is formed in the operation of the pyrophorus; for the experiments made by Stahl demonstrate, that the vitriolic acid engaged in any basis quits that basis, and unites with the inflammable principle whenever the circumstances necessary for that union concur; as they all do in this case; and therefore sulphur must be really formed. Besides, although we had not this proof of it, the sulphureous flame seen above the matrafs in which the pyrophorus is made, the peculiar smell of sulphur which the pyrophorus when burning exhales, and, lastly, the possibility of obtaining sulphur ready formed, would sufficiently demonstrate this truth. See SULPHUR.

In the second place, probably the whole vitriolic acid of the alum is not employed to form sulphur in the operation of the pyrophorus; not because a sufficient quantity of inflammable principle is not contained in the vegetable or animal matter with which it is mixed; but rather because a sufficient time is not given for that purpose, as we shall presently see.

These preliminary remarks being made, we observe, that probably the portion of vitriolic acid of the alum, which has not had time to form perfect sulphur, being partly disengaged from the earth by the action of fire, and by the presence of the inflammable principle; and being also greatly dephlegmated, since it is in a dry state; is capable of uniting with the moisture of the air as soon as it is exposed to it; and with such activity, that a heat is produced sufficient to kindle the sulphur and a very combustible fuliginous matter which are contained in the pyrophorus. This is the explanation given by Mr. Lejay de Suvigny; and is confirmed by the following observations.

First, the pyrophorus can be made only with substances fit for producing sulphur, or with sulphur itself, as Mr. de Suvigny has shewn.

Secondly, no pyrophorus will be produced, if the mixture be calcined by too long or too violent a fire; because then the whole vitriolic acid can be combined into perfect sulphur, and consequently is engaged, and not in a proper state to attract the moisture of the air; or else if it does not combine into sulphur, it being half disengaged from its basis, is driven off by the violence or long continuance of the fire; and, consequently, after this complete calcination, no acid remains partly disengaged, as it ought to be, that it might unite with the water with sufficient activity.

Thirdly, when the pyrophorus is very slowly moistened, as when it is kept in a bottle not well closed, it does not kindle, because sufficient heat is not produced by this slow and gradual attraction of water. It is also spoiled and rendered incapable of kindling, when exposed to the open air; because its acid becomes then saturated or nearly saturated with moisture, and cannot therefore unite with that of the air with sufficient activity.

Fourthly, a pyrophorus thus spoiled by exposure to moisture may be restored to its peculiar properties by making it again red-hot in a matraís; since by this calcination its partly disengaged acid is again concentrated, and resumes all its force of combining with water.

Fifthly, the inflammation of the pyrophorus is accelerated by placing it upon paper a little wetted, or by breathing upon it; because the acid then attracts the moisture more hastily, and consequently with more heat.

All these facts clearly prove, that the pyrophorus is inflamed by the extreme heat excited in its parts, from the singular force and activity with which it seizes moisture. But further, as Mr. de Suvigny well remarks, the pyrophorus can only contain the basis of the vitriolic salt employed, the earth of the vegetable or animal substance which furnished the inflammable matter, a coal, some perfect sulphur, and some imperfectly formed sulphur or vitriolic acid, which is but imperfectly engaged either by its basis or by phlogiston. Now of all these substances, the acid only, which is also very concentrated, can attract moisture so forcibly as to produce great heat. To this portion then of  
vitriolic

vitriolic acid we must attribute the spontaneous inflammation of the pyrophorus. See ACID (VITRIOLIC), PHLOGISTON, and SULPHUR.

DLXXIII. P Y R O T E C H N I C K S. This Greek name, signifying the *art of fire*, has been given to chemistry, because most chemical operations are made by fire: but it is now confined to the art of composing fire-works. See POWDER (GUN).

DLXXIV.

## Q.

DLXXIV. **Q U A R T A T I O N.** Quartation is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold allayed with silver is to be parted, we are obliged to facilitate the action of the aqua fortis by reducing the quantity of the former of these metals to one fourth part of the whole mass; which is done by sufficiently encreasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See PARTING.

DLXXV. **Q U A R T Z.** Quartz is a hard vitrifiable stone, something intermediate betwixt rock-crystals and flints, or opaque vitrifiable stones. Quartz is a stone well known by metallurgists, mineralogists, and miners, as it is frequently and abundantly found with ores, of which it often forms the matrix. It is also frequently found where no ores are.

The most common quartz is more or less of a milky-white color, and consequently semi-transparent. Some of them have various colors. This stone, which is very hard and very compact, is nevertheless cracked throughout its substance; to which also the rock-crystal is very liable, but much less so than quartz. The fragments of quartz are always angular, and its internal surface has but little gloss. Quartz is a little waved, and has a greasy appearance. It is found not only of various colors but also of various forms. It is frequently found crystallized in caverns and flits of rocks. Its crystallization is the same as that of rock-crystal. Quartz may be employed in vitrification, as all other vitrifiable stones are. See EARTHS (VITRIFIABLE) for the nature and properties of quartz; and also the mineralogy of Wallerius, and the *Dictionnaire d'Histoire Naturelle de M. Bomare*, for the different kinds of it.

(\*) Quartz is a stone of the kind called others have a granulated texture, and lastly by authors *siliceous* or *vitrifiable*. Some of some have a sparry or laminated texture, these stones consist of impalpable particles. When pure, they are white and opaque, or

**DLXXVI. QUICKLIME.** This name is given to all the earths and stones which have acquired, by exposure to a certain heat, the following properties. [*Concerning the properties of these earths before calcination, see the article EARTH (CALCAREOUS)*].

These stones by calcination lose half of their former weight, and much of their hardness. This alteration shews that the calcareous stones, before calcination, are not a pure earth, but a compound of a fixed earthy matter and of some volatile substance, of which they may be deprived by fire.

After the calcination has been completed, and the stones are become cold, if water be applied to them, it penetrates them with considerable heat and violence, divides and separates their parts, and reduces them to a very fine paste, if the quantity of water added has not been too great. The paste of quicklime thus flaked strongly retains the water, and when mixed with sand or with pounded baked clay, it becomes very hard in a certain time. This mixture is called *mortar*.

The water employed to flake the quicklime dissolves a part of it, and is called *lime water*. When this water is exposed to evaporation, a semi-crystalline pellicle is formed on its surface, which is the dissolved quicklime: this pellicle soon falls to the bottom, and another is formed on the surface, till almost all the earthy matter once dissolved be separated from the water. Lime-water has a sharp, urinous taste, which the calcareous earth had not before calcination.

The flaked lime by another calcination is reduced to the state of quicklime, as it was before.

Quicklime combines with the moisture of the air which it seems capable of attracting. By the moisture thus attracted, the weight of the quicklime is doubled, its bulk is also increased, its parts are very much divided, and it is reduced to an exceeding fine powder. In this state it is called *lime flaked in the air*.

Lime flaked in the air may be reduced, by another calcination, to its former state of quicklime, in the same manner as lime flaked by water.

Quicklime is capable of uniting with certain substances, (as, for instance, with sulphur, with which it forms an *earthy liver of sulphur*) to which the uncalcined calcareous earth could not unite so intimately.

they are colorless and transparent. When mixed with calxes of iron or of copper, they are black or red. This stone does not decay in the air, as some other siliceous stones do. According to Cronstedt, it always forms hexagonal prisms, pointed at one or both ends, when there has been no interruption to its crystallization; and this crystallized quartz is rock-crystal, which, like the uncrystallized quartz, is colorless or colored, transparent or opaque. See CRYSTAL.

Wallerius says, that every quartz is fusible by fire: but probably the quartz colored by metallic calxes are only fusible; for Mr. D'Arcet found that the transparent and

semi-transparent quartz, and also the opaque white quartz, were rendered friable, but were not fused by a very violent and long continued fire; and that by the same fire the form and transparency of rock-crystals were not altered. *Memoir sur l'Action d'un Feu Violent, Egal, & Continué, &c. Mem. de l'Acad. des Sc. 1766.*

Beccher and Hærne say, that from quartz a small quantity of alkali may be obtained by distillation or by frequent extinction of the heated stone in water. A similar alkaline matter is said to be obtainable by distillation from flints.



An important question deserves to be examined, concerning the nature of the volatile substance of which calcareous stones are deprived by fire, and whether the separation of this volatile matter is the cause of the phenomena produced by quicklime.

As the properties of quicklime resemble much those of saline substances, and as even a kind of saline matter is obtained from it, most chemists have believed, that all calcareous stones contain more or less of some salt; which being mixed with an earthy matter, cannot shew its properties till it has been partly unfolded and disengaged by the action of fire. Their opinion is grounded on some saline matter obtained from calcareous stones by distillation with a violent fire, or from quicklime after its calcination.

Van Helmont. and after him Daniel Ludovicus, pretend to have made an experiment from which they have inferred a peculiar opinion. These chemists, having exposed lime-stone to a violent fire in a retort, obtained only a pure water; and they affirm, that the remaining stone was not by this operation converted into quicklime. This experiment, together with some marks which may be perceived of inflammable matter being contained in lime-stone, has induced them to believe, that this inflammable matter is so intimately united with the saline part of the lime-stone, that this cannot exert its properties; and that this matter being, like coals, incapable of combustion in close vessels, it cannot disengage the saline part, that is, quicklime cannot be made, but by calcination in open fire.

Mr. Macquer has repeated this experiment, as may be seen in his *Memoir upon Quicklime*, (*Memoirs of the Academy of Sciences*, 1747) and found it to be only true in part.

This chemist, having exposed lime-stones in a retort to a violent fire continued during six hours, obtained a purely aqueous liquor, which shewed no saline property, and observed that the remaining stone, though not entirely converted into quicklime, had nevertheless acquired all the properties of quicklime in a great degree. The calcination was therefore found to succeed in close vessels without the combustion of any inflammable matter contained in the stone. See CALCINATION.

We are certain therefore, that the experiment of Van Helmont and of Ludovicus proves nothing in favor of their opinion

Stahl believes, with more probability, that all the properties of quicklime proceed merely from such a division and disjunction of the integrant parts of the calcinable earth, by means of the calcination, that they are rendered capable of uniting with the particles of water. He believes that this union is already begun in lime-stone; that the fire, during the calcination, does only separate the principles of this compound body, that is, expels the watery part, which being volatile, is incapable of resisting the action of fire, and separates it from the earthy principle, and does not deprive the latter principle of its disposition to unite with the former, but rather encreases this disposition by attenuating the earthy matter. This theory explains in a satisfactory manner all the phenomena of quicklime.

All the properties of calcareous stones by which they differ from vitrescible stones, that is to say, their inferior degrees of hardness and of weight, and the

less of matter which they sustain by violent fire [See EARTH (CALCAREOUS), and EARTH (VITRIFIABLE)] shew, that they contain a principle less hard, less weighty, and less fixed than pure earth: but these are precisely the essential properties which constitute the difference betwixt earth and water.

In fact, the experiments of Van Helmont, Ludovicus, and of Mr. Macquer shew, that water is the principle separated from lime-stone during its calcination.

The difficulty with which fire expels all the watery part of lime-stone shews, that in this stone there is at least some degree of the union of composition, and a true adhesion betwixt the integrant parts of water and those of earth, and also gives an instance of the great degree of fire which water is capable of sustaining when it is retained by means of an union contracted with a fixed matter. The degree of heat sustained by water on this occasion must necessarily enable the water to separate more and more the integrant parts of the earthy matter, and to break their aggregation (in the Digestor of Papin), and to give it consequently a greater disposition to re-unite with water.

This being established, if we add to quicklime the watery principle which the violence of the fire has expelled, the earthy particles having acquired by calcination a strong disposition to unite with water, these two substances will accordingly unite together with great activity; and as the primary molecules of the two uniting substances are very hard, the friction occasioned by their motion during their union must produce a considerable heat.

This new union contracted by the parts of quicklime with water is much more perfect and more intimate than the union of the constituent parts of the lime-stone before calcination. As water and earth are the two elements of saline substances (see SALT), a new, at least, a beginning combination must be formed by the extinction of quicklime. In consequence of this combination, a taste is given to lime-water, and *cream of lime* is produced, which is soluble in water, and separable from thence like a true salt, and which must be considered as a saline matter, begun at least, and overcharged with the earthy principle.

It appears certain that the cream of lime is not produced by any salts originally mixed with the lime-stone, unfolded by the action of fire, and thereby restored to their properties and solubility in water; for it is not credible that at least the greatest part of the saline matter, which may have been originally mixed with the calcareous earth of lime-stones, should not have been already washed away by the water to which these stones have been often exposed since their formation. Besides, supposing even that some of that saline matter should have remained, certainly it would be all washed out by one calcination of lime-stone, and extinction in water: but we know that quicklime once extinguished, and boiled in any quantity of water, may, by another calcination, be restored to the state of quicklime, and to the property of solubility in water, and of producing cream of lime as much as before. This phenomenon affords an additional proof, as well as an explanation of the theory of Stahl.

Further, the addition of any saline substances to lime-stones, which when calcined yield but a weak quicklime, not only does not render the quicklime more strong and active, but, on the contrary, considerably injures its quality.

These

These facts have been advanced by Mr. Macquer, in his Memoir upon Quicklime, and they shew that the properties of calcareous stones acquired by calcination are not occasioned by the presence of any saline matter.

The firm adhesion of the water to flaked quicklime deserves attention, and is so considerable, that the water cannot be entirely separated but by a fire as violent as is required for the first calcination of lime-stone.

Mr. Duhamel has made a decisive experiment to shew the strength of this adhesion.

Having weighed an ounce of flaked quicklime, which had previously undergone several strong calcinations to deprive it of all its water; and observing that each ounce of this quicklime, notwithstanding all these calcinations, retained more than three gros and thirty-eight grains of water, he exposed it again to a very violent fire in a melting furnace, and found that notwithstanding this further calcination, his ounce of quicklime still retained twenty grains of moisture. (*Mem. of the Acad. of Sc. 1747*).

This retention of the water united to quicklime during its extinction may be naturally deduced from the adhesion contracted between earth and water; which two substances really form a new compound consisting of two principles, one of which is fixed, and the other is volatile, and in which the volatile part is retained by the fixed part with a strength proportionable to the perfection of the combination of these two substances. Hence we may explain the cause of the difficulty of drying flaked lime, and of the several phenomena before related which happened upon exposure of quicklime to air, and also of several other properties hereafter to be mentioned, all which shew the saline quality of this substance. It unites to all acids with the same phenomena, as it does before calcination: and the neutral salts with earthy bases, which are formed by the calcareous earth in these two states, are very similar to each other. [*See SALTS (NEUTRAL) with EARTHY BASES*].

Nevertheless it seems as if the acid of all those salts, the basis of which is quicklime, adheres more strongly than the acid of salts, the basis of which is uncalcined calcareous earth.

Lime-water, which keeps dissolved the most attenuated and most saline portion of the quicklime, as we have already shewn, decomposes all salts with metallic bases.

Lastly, quicklime produces alterations upon fixed and volatile alkalis, which cannot be effected by uncalcined calcareous earths.

Fixed alkalis, treated with quicklime, become much more difficult to be dried, more deliquescent, more caustic, and much more powerfully solvent. The same alterations are produced by means of quicklime upon volatile alkali, which is thereby rendered much more penetrating, and so strongly deliquescent that it cannot be then obtained in a concrete state.

These changes are probably produced by the quicklime depriving the alkalis of some inflammable matter; and as probably the remaining inflammable matter is a constituent part of these alkalis, we need not be surprised that their properties are changed, and that even a decomposition of their parts should happen upon the quicklime depriving them of this inflammable matter, if the action of the quicklime be sufficiently applied. And accordingly it happens that by

a continued treatment of fixed and volatile alkalis with quicklime, they may be at last entirely destroyed.

As simple calcareous earths do not produce the same effects upon alkalis, it follows that quicklime has a more powerful action than those earths upon inflammable matters; and accordingly we find that quicklime unites more intimately than calcareous earths with oils and with sulphur, forming with this latter substance a kind of earthy liver of sulphur, which is soluble in water to a certain degree.

This action of quicklime upon alkalis and upon inflammable matters is advantageously applied to give activity to the former, and to make them more capable of uniting with oils. Accordingly, the alkali employed in the composition of soap ought to be always sharpened by quicklime. See SOAP, and *LEY of SOAP-BOILERS*.

Fixed alkali sharpened by quicklime, and reduced to a solid consistence by drying, is much more caustic than ordinary alkali, and is employed as a cautery. See CAUSTIC (COMMON).

The most general use of quicklime is for building. The property which slaked lime has, when mixed with sand, of forming a *mortar* or cement capable of hardening and acquiring a stoney consistence, renders it useful for the joining of stones of buildings, pavements, &c. This mortar has also the advantage of being impenetrable by water, when it has once become solid. See MORTAR.

Quicklime has medicinal virtues. As an absorbent earth, it is anti-acid, and is capable of absorbing any acids which are produced in the stomach by a debility of that organ, in the diseases proceeding from a spontaneous acid, so well described by Boerhaave. It is so much better adapted to those diseases which are always caused by inactivity, and by the weakness and laxity of the fibres, as it has a tonic quality, which simple absorbent earths have not. See EARTHS (ABSORBENT).

As quicklime is also drying, and somewhat caustic, and consequently cicatrifying, it may contribute to the cure of certain ulcers, especially of the soft parts: accordingly several able physicians have prescribed it successfully even for internal suppurations, and for the phthisis of the lungs.

Lastly, the property which quicklime has of attenuating viscid matters, and of decomposing ammoniacal salts, has been advantageously applied in these later times to dissolve stones in the kidneys and bladder. An English physician has made on this subject some experiments capable of giving hopes of success; and M. Roux, Doctor-Regent of the Faculty of Medicine at Paris, who has also given other proofs of his chemical abilities, has added considerably to these experiments; a relation of which, with his own additions, he has published in French (1)

(1) The experiments made by Dr. Black on quicklime, and related in the Essays physical and literary published at Edinburgh, have enabled that excellent chemist to form a new and satisfactory theory of the changes produced upon calcareous earths by means of calcination, and of those produced upon alkalis by means of quicklime. These we have already mentioned under the articles AIR

(FIXABLE), ALKALIS (FIXED and VOLATILE), and some others. We shall nevertheless place under one view the principal facts and doctrines concerning quicklime, and for more minute explanations and proofs, we refer to the above-mentioned articles, but especially to the Essay itself above-quoted.

The best method of administering quicklime, especially for internal use,

The class of earths and stones called by naturalists *calcareous*, or chalks and marbles, or those which by calcination are convertible into quicklime, are found by experiments to consist of the following component parts. 1. Of *quicklime*, or pure and uncombined calcareous earth. The quantity of this in a piece of chalk was found by Dr. Black to be equal to  $\frac{6}{11}$  of the whole, the remaining  $\frac{5}{11}$  parts having been extricated by calcination. 2. Of *fixable air*, which when extricated is found to be permanently elastic, and unflammable. Concerning its properties, see AIR (FIXABLE). The quantity of this air extricated from a piece of chalk, during its solution in an acid, was found by an experiment of Dr. Black to be equal to  $\frac{1}{3}$  of the whole mass; and the quantity of air extricated from a piece of marble was found by Mr. Cavendish to be  $\frac{1}{10}$  of the whole mass. As the results of the experiments made by these two gentlemen so nearly concur, we have reason to believe that mild calcareous earth is always united and saturated with a determinate quantity of fixable air. 3. Of *water*. A certain quantity of water is always extricated from calcareous stones during their calcination, and may be collected by distillation of these stones with a retort and receiver. The quantity of water obtained from the distillation of osteocolla, which is a calcareous earth, by Mr. Margraaf, was found to be equal to  $\frac{1}{2}$  of the whole mass. Dr. Black found that chalk lost by calcination  $\frac{1}{4}$  of its weight. If we deduct from that loss, the  $\frac{1}{3}$  which he found by an experiment above-mentioned was the quantity of fixable air contained in chalk, the remainder  $\frac{1}{12}$  or  $\frac{1}{6}$  will be the quantity of water, which is nearly equal to the quantity obtained from osteocolla. Hence also we have reason to believe that a certain determinate quantity of water is united with and saturates the calcareous earth, when mild, or united with fixable air. But when this earth is separated from its fixable air, it becomes then capable of uniting with a much larger quantity of water, which is also probably determinate, as we shall find when we consider the properties of quicklime.

These are the only component parts of the purer chalks, marbles, calcareous spars, and

stalactites; but many of the stones and earths which are usually calcined for making quicklime, as many of the common lime-stones and marbles, contain, besides the earth properly called calcareous, various other substances intermixed, as sand, or vitrifiable earth, clay, and metallic calxes. Some of these, as sand and metallic calxes, if not in too large quantities, are useful ingredients in the composition of mortar. But we must in this article be understood to mean calcareous earth unmixed with any other matters. The quantity of calcareous earth in any lime-stone may be discovered by observing how much of that stone is soluble in marine or nitrous acids, and by adding to the solution of the calcareous earth some caustic volatile alkali, by means of which, if any other earth, as earth of alum, metallic earths, &c. have been dissolved by the acid, these will be precipitated, and the calcareous earth alone will remain dissolved. By comparing the weight of the stone originally employed with the weight of the undissolved and precipitated parts, the quantity of calcareous earth in that stone may be found: or this quantity may be precipitated from the acid in which it is dissolved, by adding to the above solution of calcareous earth some mild fixed or volatile alkali, till no further precipitation is occasioned.

Native calcareous earths and stones may be decomposed, or resolved into the above-mentioned component parts, by fire or by acids.

When they are exposed to fire, the water and the fixable air are volatilised, and separated from the earthy part, which remains singly, and is then quicklime.

When an acid is applied to native calcareous earths, their fixable air is disengaged, recovers its elasticity, and is dissipated, while the acid remains united with the earth and the water, forming a salt with basis of calcareous earth. See SALTS. The earth or quicklime may be separated from the acid by means of a fixed alkali, which having a greater disposition to unite with the acid, precipitates the earth. If the alkali employed be caustic, or deprived of fixable air, the earth precipitated will be also caustic, or quicklime. But if the al-

kali.

is lime-water, because this water has all the medicinal properties of quicklime,

kali employed be mild, that is, combined with fixable air, this air will unite with the earth; and thus the quicklime will be rendered mild, or restored to its original state of native calcareous earth, combined with air.

Quicklime has the following properties.

1. It is entirely soluble in water, with which it unites so rapidly, as to occasion considerable heat. When exposed to air, it imbibes moisture from thence. When united with as much water as is sufficient to make it a fluid paste, it is called *slaked lime*. Water saturated with quicklime is called *lime-water*. According to Brandt, lime-water contains about one part of quicklime to seven or eight hundred parts of water. Slaked lime, or lime-water, being exposed to the atmosphere, attract from thence particles of fixable air which float in it, by which means the quicklime is rendered mild, unsoluble in water, and therefore appears on the surface of the lime-water or of the slaked lime where this combination happens, in the state of mild or combined calcareous earth, convertible by a second calcination into quicklime, and is called *cream of lime*.

If the earth dissolved in lime-water be precipitated from thence by any substance containing fixable air, as by mild alkalis, or magnesia, it will unite with this air, become mild, and resume its former weight and properties which it possessed before calcination. But if it be precipitated from the water by means of some substance which does not contain fixable air, but which is more strongly disposed than the earth to unite with the water, for instance, spirit of wine, the earth thus precipitated will be in the state of quicklime, that is, caustic, and soluble in water.

2. Quicklime unites with acids without effervescence, which is nothing else than an extraction of the fixable air, of which quicklime has been already deprived. It nevertheless saturates as much acid as it would have done if it had not been calcined.

3. Quicklime is more powerfully disposed to unite with fixable air than fixed or volatile alkalis, or magnesia. Hence,

when treated with these substances, it takes from them their fixable air, and is itself rendered mild, and restored to its original weight and properties. Thus two drams of chalk, having been by calcination reduced to one dram and eight grains of quicklime, were thrown into a filtrated solution of an ounce of mild fixed alkali in two ounces of water, and digested during some time; by which the calcareous earth became mild, and weighed one dram and fifty-eight grains. By means of magnesia, the calcareous earth may be precipitated from lime-water, and this earth is found to be mild, and to have deprived the magnesia of its fixable air. By depriving alkalis of their fixable air, quicklime renders them more caustic and solvent, for the same reason that itself is by this privation of air rendered more caustic and powerfully solvent. This increase of causticity and dissolving power is consistent with a general rule, namely, that the more simple or less compounded any body is, that is, the less its general tendency to union is satisfied, the more disposed it is to unite with or dissolve other substances. See AIR (FIXABLE), ALKALIS.

4. Quicklime has a disposition to unite with sulphur, with which it forms a hepar of sulphur, similar to that made by sulphur united with an alkali, and, like this, soluble in water. It is also disposed to unite with oils and with animal and vegetable matters, by which means it possesses a caustic and corrosive property.

5. Quicklime mixed with sand forms a mass which hardens, and is used as a cement or mortar. The hardening seems to be occasioned by a crystallization of the calcareous earth when the superfluous water is exhaled, and is similar to the hardening of calcined gypsum or plaster of Paris, when mixed hastily with a sufficient quantity of water to effect the crystallization of its minute particles. The use of the sand added to quicklime in making mortar is to prevent those cracks which would be formed by the drying of the calcareous earth, and by which its cohesion would be greatly diminished. This effect the sand produces, by diminishing

and because the parts of the quicklime dissolved in it are exceedingly fine, and consequently perfectly distributed. See WATER (LIME).

nishing the proportion which the contraction of dimensions, occasioned by drying, bears to the dimensions of the whole . mass, which is to be thus exposed to contraction and drying ; the sand being itself incapable of suffering any contraction.

## R.

DLXXVII. **R** A I N. See WATER.

DLXXVIII. **R** E A L G A R, or REALGAR. These names have been given to compositions of sulphur and arsenic. These two substances are capable of uniting together, especially when they are reduced to vapors, and sublimed together. The whiteness of crystalline arsenic is always altered by union with sulphur; and the new compound becomes yellow, inclining more or less to an orange, or even to a red color, according to the quantity of sulphur united with the arsenic. When the sulphur is only a tenth part of the whole mixture, the sublimate is yellow. It is then called *yellow realgar*, or *yellow arsenic*, and in commerce *orpiment*.

When the sulphur is a fifth part of the combination, the sublimate is red. It is then called *red realgar*, *sandarach*, *red arsenic*, &c. To few substances have so many names been given as to arsenic and its compounds, as may be seen in several authors of mineralogy, and particularly in Henckel's Pyritologia.

As sulphur fixes arsenic a little, the red realgar may be melted with a gentle heat; and when it has become solid, it is transparent, and then is called *ruby of sulphur*, or *arsenical ruby*.

These combinations of arsenic and sulphur are not generally made in laboratories, because they do not succeed well, as Henckel remarks, when pure arsenic and pure sulphur are sublimed together. They are prepared in countries abounding in ores, which are smelted by mixing together some that contain arsenic, as the *white pyrites*, with others that contain sulphur, like the *sulphureous pyrites*, or *sulphureous scorias*, the quantity of each of which is proportioned as experience taught.

These artificial combinations of sulphur and arsenic ought to be distinguished from those which nature offers to us ready made, as orpiment. They have been very improperly confounded by several authors. Both the natural and artificial compounds are poisons, although Hoffman says that the natural orpiment



piment is not poisonous. The yellow and red artificial arsenics are probably more pernicious. The principal use of these substances is for painting.

When arsenic and sulphur are thus well combined together by sublimation, they cannot be separated without some intermediate substance, because they are volatile: but this separation may be effected by means of fixed alkali or mercury. See ARSENIC.

**DLXXIX. RECEIVER.** Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

Receivers ought to be made of glass, not only because this matter resists the action of the strongest and most corrosive substances, but also because being transparent it allows the operator to see through it, and to judge by the frequency of the drops, if the distillation be too fast or too slow, and also if the quantity and nature of the substances which come over be such as is required.

Almost all receivers are kinds of bottles of different sizes, of a spherical form, the necks of which are cut short, and each of which is pierced with a small hole in its lateral or upper part, to give vent to the air or vapors which are too expansive. Receivers of this form are called *balloons*. See BALLOON.

Some receivers are matrasses with long necks. These are generally adapted to the beaks of glass alembics. This long neck serves to keep the belly of the receiver, where the liquor is collected, at a proper distance from the fire.

Receivers have different forms for particular operations. Such are those which have two or three beaks, either to be adapted to other receivers, or to admit at the same time the necks of several distillatory vessels, when the intention of the operator is that the vapors of different substances should meet in the same receiver. Such also are *receivers for essential oils*, which are very convenient for the distillation of these oils. To obtain the essential oil of aromatic plants, these plants must be distilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, rises in distillation, carrying with it the essential oil, which also has the property of rising with this degree of heat. See OILS.

As a large quantity of water must be employed, that the plant may always be kept immersed in the alembic, and consequently as a good deal of it rises in proportion to the oil, any receiver of ordinary size would be soon filled with water, with a little oil floating upon its surface; and would require to be frequently changed, which would be very troublesome, and would occasion a loss of part of the oil.

These inconveniencies are avoided by using receivers contrived purposely for such distillations. They are so made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glass cucurbits, which contract as they rise higher; so that their neck or upper opening is but nearly of a convenient size to receive the beak of the *worm*. These receivers have another opening about the middle of the swelling or belly; and to this opening is joined a glass tube, which bends and rises vertically along the outer part of the receiver, so as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the side opposite

to the body of the receiver, to pour into another vessel the liquor which rises there. It forms the figure of S.

When this receiver is to be used, it is to be placed vertically under the beak of the worm. During the distillation, the liquor rises to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it must begin to flow from the mouth of this tube into another vessel placed on purpose to receive it: but as essential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which discharges itself through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with such a receiver, we may distill without the trouble of changing the vessels; which is certainly very advantageous.

**DLXXX. RECTIFICATION.** By rectification is meant the exact purification of certain substances, by means of *distillation* or of *sublimation*.

This operation is necessary to disengage many chemical products or agents from a mixture of extraneous matters which destroy their purity. Thus, for instance, vitriolic acid, when first obtained from *vitriol* or from *sulphur*, is always charged with a considerable quantity either of inflammable matter, which renders it black and sulphureous; or of superabundant water, which weakens it. It is separated from both these matters by a second distillation, in which they being more volatile than the acid, are carried off; which second distillation is called *concentration* or *rectification of vitriolic acid*. See CONCENTRATION of VITRIOLIC ACID.

Also when animal and vegetable matters are decomposed by distillation, all the portion of oil that is not volatile contained in these substances does not rise but with a degree of fire so strong as to burn a part of them, and to raise along with them a considerable portion of saline substances, which, being mixed with the oily part, considerably alter its purity. To purify these oils, which, from their burnt smell, are called *empyreumatic*, new distillations must be applied, in which, by means of a less heat, the most volatile and purest part of these oils is separated from the most empyreumatic and saline parts, which remain at the bottom of the retort: this is called the *rectification of empyreumatic oils*. See OIL (RECTIFIED ANIMAL) or of DIPPEL.

The ardent spirits obtained by a first distillation of liquors which have undergone the spirituous fermentation, are overcharged with a large quantity of phlegm and light oil, which rise along with them in this first distillation. The product of this distillation is called *aqua vitæ*. It is an ardent spirit very far from the degree of dephlegmation and purity which good spirit of wine ought to have to render it fit for chemical operations, and for several compounds commonly used, such as perfumed waters and *liqueurs* for the table. This spirit of wine is to be purified, or rather the *aqua vitæ* is to be changed into spirit of wine by new distillations, slowly conducted with a gentle fire and water-bath, by means of which the most volatile part that always rises first with the least heat, and which is the true spirit of wine, is separated from the less volatile part that remains in the alembic, and which contains the phlegm and oil

oil of wine, by which the spirit of wine was rendered impure. The first liquor of these second distillations or rectifications is called *rectified spirit of wine*. For its properties see SPIRIT (ARDENT).

When only a small quantity of spirit of wine is to be rectified, the operation is difficult, especially when we would have it perfectly rectified. The cause of this difficulty proceeds from the very small quantity of the first liquor obtained in this rectification. Several chemists, to obtain a larger quantity of the first spirit, propose to mix with the spirit of wine some intermediate substances to absorb and retain its phlegm and oil, such as dried and calcined salts, very dry chalk, &c. Kunckel proposes to separate more effectually the oil, by adding to the spirit a large quantity of water, and by distilling this diluted spirit with a very gentle heat. This method is indeed very capable of facilitating the separation of the oil of wine from the spirit of wine; because this oil certainly adheres to the spirit, which is the chief obstacle to its separation; and because the spirit of wine has greater affinity with water than with oil; so that when it is diluted with much water, it quits the oil to unite with the water. This expedient of Kunckel is therefore very good to facilitate the separation of spirit of wine from the oil which renders it impure; but, on the other hand, when it is practised, we are afterwards obliged to deprive the spirit of wine of the water with which it was diluted.

All this trouble and inconvenience may be avoided by rectifying at once a large quantity of aqua vitæ. Nothing more is required to obtain at once a considerable quantity of pure spirit of wine, than to set aside the twelve or fifteen pints first drawn over from a large quantity, suppose from three hundred pints of aqua vitæ, distilled with a very gentle fire in a large alembic. As the most spirituous, least aqueous, and least oily part of it always rises first, these twelve or fifteen pints are perfectly rectified spirit of wine, especially when the heat has been well conducted. By thus keeping apart portions of the spirit obtained at different times, we may have spirit of wine of the several degrees of strength and purity. The weaker spirit may, by another distillation, be again rectified. Lastly, the spirit of moderate strength may be preserved, as it is fit for many uses. This method is followed by Mr. Beaumé in the rectification of spirit of wine, and is certainly the most convenient and the best.

The volatile salts obtained in the decomposition of certain oily substances, as volatile alkalis, from decomposed animal matters, are always very impure, and spoiled by much fetid empyreumatic oil, which rises along with them. They are purified and disengaged by subjecting them to new distillations or sublimations with a well conducted heat. The same observation is applicable to butter of antimony, artificial cinnabar, phosphorus, and of many other chemical products, which are always impure when obtained by a first operation, and must therefore be purified by a second distillation or sublimation. All these second operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We shall not therefore enter into the details of them; but we shall observe only, that all rectifications are founded upon the same principle. They all consist in separating substances more volatile from substances less volatile; and the general method of effecting this is to apply only the degree of heat which is necessary to cause this separation. See DISTILLATION and SUBLIMATION.

DLXXXI. R E D. (*m*)

DLXXXII. REDUCTION or REVIVIFICATION.

This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such: but custom confines it to operations by which metals are restored to their metallic state after they have been deprived of this state, either by the loss of their phlogiston, as metallic calxes, or by the union of some heterogeneous matters which disguise them, as *fulminating gold*, *luna cernea*, *cinnabar*, and other compounds of the same kind. These *reductions* are also called *revivifications*. We shall treat of both these kinds of reduction.

The reduction of metallic calxes regards only imperfect metals; because these alone are susceptible of losing their metallic properties by the loss of phlogiston. They may be deprived of this principle by the action of air or of water, which changes them to *rust*; or by the action of acids, particularly of the nitrous and vitriolic; or, lastly, by ordinary calcination, that is, by the combustion of their phlogiston in an open fire.

Metals deprived of their phlogiston by any of these causes have not their peculiar color, lustre, ductility, nor even consistence and gravity. They have the appearance of earths, the parts of which are unconnected, unless they have sustained a fire violent enough to fuse them; and then they become brittle vitrified matters.

But these metallic earths, calxes, or glasses, are capable of being again combined with the inflammable principle, and of recovering all the metallic properties. For this purpose their calcination or dephlogistification must not have been too compleat, and the phlogiston must be applied in a state favorable for combination. These calxes, particularly those of metals which cannot be radically calcined, as lead, bismuth, iron, and copper, may recover their phlogiston, and may be reduced even without fire or fusion, merely by the contact of phlogistic vapors; for instance, by the vapor of liver of sulphur; or they may be reduced in the humid way, that is, when they are precipitated by some substance capable of applying phlogiston to them.

But we must observe, that metals reduced by either of these methods are only superficially so, when the metallic masses are considerably large; and that when the metals thus reduced consist of fine molecules, these molecules, although well reduced and provided with all their metallic properties, remain always disjoined and separated from each other; either because they are not small enough, or because they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by these methods: but the operations of our laboratories are very different from those of nature. Accordingly, in practical chemistry a much more expeditious method for making these reductions is employed; which is fusion.

The reduction of metallic calxes by fusion is generally a quick and easy operation. It, however, requires certain attentions and management; which

(*m*) RED. Concerning the substances which give a red color to stuffs, glass, enamels, &c. see the articles FLOWERS, FRUITS, COCHINEAL, MADDER, KERMES, LAC, DYING, MANGANESE, POWDER of CASSIUS, ENAMEL.

are :

are : 1. To mix accurately the metallic calx to be reduced with the proper quantity of the matter which is to give it phlogiston. 2. To add to the mixture some saline or vitreous matter capable of facilitating the fusion and separation of the reduced metal from the scoria. 3. To prevent any communication with external air, that the phlogiston may not be burnt and consumed. 4. To keep the fire low at first, that the too great swelling, which is generally occasioned by the re-action of the inflammable principle with metallic earths, may be prevented; and to raise the fire towards the end, so that not only the metal, but also the supernatant scoria, may be perfectly fused; whereas if the scoria was not well fused and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

The operations must be very exactly performed, especially in essays of ores, in which the precise quantity of metal is required to be known. These essays of ores are in some measure the only reductions of this kind which are performed in practical chemistry, as the reduction of pure metallic calxes differs only from the former in requiring a less quantity of flux; because these calxes do not, as the ores do, contain a difficultly fusible earthy or stony matter: we therefore refer to the article *ESSAY of ORES*. Here we shall only observe, that when we treat very volatile semi-metals, as zinc and arsenic, the reduction ought to be made in vessels perfectly close; for instance, in an earthen retort. We find after the reduction these metallic matters sublimed in the vault or neck of the retort.

The reduction of metals which do not lose their inflammable principle, as gold, silver, and mercury, is of another kind. As these metals can be only disguised by the union they have contracted with some heterogeneous substance, they are to be reduced, not by restoring phlogiston, but by some intermediate substance capable of separating from them the matter which is united with them. These intermediate substances must therefore differ according to the matter united with the metal.

For instance, fulminating gold may be reduced by fusing it with sulphur, or with fixed alkali; because either of these substances is capable of decomposing the nitrous ammoniacal salt which gives the fulminating property to gold. See *GOLD (FULMINATING)*. Luna cornea also is reduced by fusing it with a large quantity, as, for instance, with twice its weight of fixed alkali; because in this reduction the marine acid united with the silver is to be separated, and the fixed alkali is capable of effecting that separation. The reduction of luna cornea is attended with difficulties, because this compound is semi-volatile and very penetrating; so that when it is exposed to fire, some part of it is always lost, whether it exhales in vapors or penetrates the crucible. Several chemists recommend the reduction of luna cornea by fusing it with fat matters, which, from experience, I know to be a very bad method; for the marine acid has a strong affinity with silver, and has no disposition to unite with phlogiston, or even with substances which contain much of it.

Luna cornea may also be well reduced by precipitation, and by treating it with other metals which have more affinity than silver with marine acid, such as tin, iron, regulus of antimony. Mr. Margraaf gives, in his *Opusculæ Chæmiquæ*, a process which deserves a place here; because, according to this excellent chemist,

mist, a very pure silver is obtained, and without any loss. It consists in mixing well, in a glass mortar, luna cornea with some concrete volatile alkali, in the proportion of about five gros of luna cornea with an ounce and a half of volatile salt, to which a little water is to be added to give to the mixture a soft consistence. This mixture swells with a kind of effervescence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a gros of volatile alkali is to be added, to replace that which is dissipated; and afterwards a larger quantity of water. Upon the addition of this water appears a fine amalgam of silver, which is to be washed several times, till the water comes off clear. This amalgam is then to be distilled, by which the mercury is expelled, and all the silver which was contained in the luna cornea remains pure, excepting about four grains which have been washed away.

The mercury of cinnabar is to be reduced or separated from sulphur, by mixing with the cinnabar any substance which has greater affinity with the sulphur than mercury has, such as fixed alkalis, absorbent earths, iron, copper, lead, silver, or regulus of antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole distilled together, by which the mercury will be raised and collected at the bottom of the receiver under some water placed there to facilitate its condensation. The sulphur of the cinnabar remains in the retort united with the intermediate substance employed for the separation. This mercury is called *mercury revived from cinnabar*. It is justly considered as very pure.

**DLXXXIII. R E F I N I N G.** Refining is a term used in chemistry and several arts to signify the purification of some substance, particularly of metals, as gold, silver, copper, iron, &c.

We shall here treat only of the refining of gold and silver; and for the refining of other substances we refer to their several articles.

Gold and silver may be refined by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus, for instance, gold, having the property which no other metal, not even silver, has, of resisting the action of sulphur, of antimony, of nitrous acid, of marine acid, may be purified by these agents from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as *purification of gold by antimony, parting, concentrated parting, dry parting*. In a similar manner, as silver has the property, which the imperfect metals have not, of resisting the action of nitre, it may be refined by this salt: but the term *refining* is chiefly applied to the purification of gold and silver by lead in the cupel. We shall therefore treat only of this latter manner of purifying these metals, referring for the others to the words **PURIFICATION and PARTING**. See these words.

The refining of gold and silver by lead in the cupel is made by the destruction, vitrification, and scorification of all the extraneous and destructible metallic substances with which they are alloyed.

As none but the perfect metals can resist the combined action of air and fire, without burning, that is, without losing their inflammable principle, their metallic properties and forms, and without being changed into earthy or vitreous matters, incapable of remaining any longer united with substances in a metallic state, there

there is then a possibility of purifying gold and silver from all alloy of imperfect metals merely by the action of fire and air; only by keeping them fused till all the alloy be destroyed: but this purification would be very expensive, from the great consumption of fuel, and would be exceedingly tedious. I have seen silver alloyed with copper, exposed longer than sixty hours to a glass-house fire without being perfectly refined: the reason of which is, that when a small quantity only of imperfect metal remains united with gold or silver, it is covered and protected from the action of the air which is necessary for the combustion of the imperfect metals, as of all combustible matters. See CALCINATION.

This refining of gold and silver merely by the action of fire, which was the only method anciently known, was very long, difficult, expensive, and imperfect: but a much shorter and more advantageous method has been discovered. This method consists in adding to the alloyed gold and silver a certain quantity of lead, and in exposing afterwards this mixture to the action of the fire. Lead is one of the metals which loses most quickly and easily enough of its inflammable principle to cease to be in a metallic state; but, at the same time, this metal has the remarkable property of retaining, notwithstanding the action of the fire, enough of this same inflammable principle to be very easily melted into a vitrified and powerfully vitrifying matter, called *litharge*. See LITHARGE.

The lead then which is to be added to the gold and silver to be refined, or which happens naturally to be mixed with these metals, produces in their refining the following advantages: 1. By encreasing the proportion of imperfect metals, it prevents them from being so well covered and protected by the perfect metals. 2. By uniting with these imperfect metals, it communicates to them a property it has of losing very easily a great part of its inflammable principle. 3. Lastly, by its vitrifying and fusing property which it exercises with all its force upon the calcined and naturally refractory parts of the other metals, it facilitates and accelerates the fusion, the scorification, and the separation of these metals. These are the advantages procured by lead in the refining of gold and silver.

The lead which in this operation is scorified, and scorifies along with it the imperfect metals, separates from the metallic mass, with which it is then incapable of remaining united. It floats upon the surface of the melted mass; because by losing part of its phlogiston, it loses also part of its specific gravity, and lastly it vitrifies.

These vitrified and melted matters accumulating more and more upon the surface of the metal while the operation advances, would consequently protect this surface from the contact of air which is absolutely necessary for the scorification of the rest, and would thus stop the progress of the operation, which could never be finished, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the vessel in which the melted matter is contained; and which being porous, absorbs and imbibes the scorified matter as fast as it is formed, or by a channel cut in the edge of the vessel through which the matter flows out.

The vessel in which the refining is performed is flat and shallow, that the matter which it contains presents to the air the greatest surface possible. This form resembles that of a cup, and hence it has been called *cupel*. See PLATE I. Fig. 10. The furnace ought to be vaulted, that the heat may be applied upon the surface

of the metal during the whole time of the operation. Upon this surface a crust or dark-colored pellicle is continually forming. In the instant when all the imperfect metal is destroyed, and consequently the scorification ceases, the surface of the perfect metals is seen, and appears clean and brilliant. This forms a kind of *fulguration* or *coruscation*. By this mark the metal is known to be refined. If the operation be so conducted that the metal sustains only the precise degree of heat necessary to keep it fused before it be perfectly refined, we may observe that it fixes or becomes solid all at once in the very instant of the coruscation; because a greater heat is required to keep silver or gold in fusion, when they are pure, than when alloyed with lead.

The operation of refining may be performed in small or in large quantities, upon the same principles, but only with some differences in the management. As the refining of small quantities of perfect metals is performed in the same manner as these metals are essayed, the essay being only a very accurate refining, we refer to the article *ESSAY of the VALUE of SILVER*.

Large quantities of silver are thus purified, after the operations by which that metal is obtained from its ores. This silver, being always much alloyed, is to be mixed with a sufficient quantity of lead to complete its purification, unless lead has been added in its first fusion from the ore, or unless it has been extracted from an ore which also contains lead; in which latter case, it is alloyed naturally with a sufficient quantity, or more than sufficient, for the refining of it. See *ORES of SILVER*. One of the ores of this kind, which is treated in the best manner, is the ore of Ramelsberg in Saxony. The several operations which are practised in this country, abounding in mines and excellent metallurgists, have been exactly described by Schlutter. We shall here give a succinct extract of the method of purifying large quantities of silver, from Hellot's translation of Schlutter's work.

The workmen give the name of *the work* to the lead containing silver, obtained by smelting the ore of Ramelsberg. The first operation, called *fining*, upon this mass of lead and silver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the surface of the metal. See *a plan and section of this furnace*, PLATE II. *Fig. 16 and 17*. This furnace is so constructed, that the flame of the wood, which is put in the fire-place through a hole called the fire-hole, is directed so as to circulate over the *work* within the furnace. The flame is thus directed by a current of air which is introduced through the ash-hole, and passes out at an opening made at the side of the place where the work is. The wood is considerably saved by this direction of the flame. In the furnace a large cupel or test is to be disposed. This test is to be made with ashes of beech wood well lixiviated, that the salt may be washed from them. See *CUPEL*. In some founderies different matters are added to the ashes, as sand, lime, clay, calcined spar or gypsum. We may observe, concerning these additions, that they would be very injurious, and would make the test melt, if a strong heat were applied; but the heat requisite for fining is only moderate. See at the word *ESSAY the inconveniences and marks of too strong a heat*.

When the test is well prepared and dried, all the *work* is to be put into it at once, which is generally sixty-four quintals: the fire is then to be made in the fire-place with faggots; but the fusion is not to be too much hastened, first, that the test may have time to dry thoroughly, which is very essential; for if  
any



any moisture remained when the metal is melted, an explosion might happen : secondly, because the *work* of the ore at Ramelsberg, and of most others, is rendered impure by the mixture of many metallic matters, which ought to be separated, otherwise they would spoil the litharge, and give a bad quality to the lead afterwards obtained from that litharge. These extraneous matters found in the *work* of Ramelsberg are, copper, iron, and matt. As these substances are hard and refractory, they do not melt so soon as the *work*, if the heat be moderate ; and besides, as they are specifically lighter than the mixture of lead and silver, they float upon the surface of these two metals when melted, in form of a pellicle or skin, which is to be taken off. These impurities are called the scum or first dross. The remainder forms also a scum, which appears when the work has received more heat, but before the litharge has begun to form. This is a scoria which is to be carefully taken off, and is called the second dross.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the surface of the metals, by means of iron plates placed for that purpose before the blast-hole, and which are called papillions. This air is not intended to encrease the fire, but to facilitate the combustion of the lead, and to push the litharge to a channel in the opposite side of the test. This channel is called *the way of the litharge*, because through this passage all the litharge, which is not imbibed by the test, flows out of the furnace. The litharge which is found in the middle of the large lumps is friable, and crumbles into powder like sand. It is put in casks, each of which contains five quintals of it, and is sold by the name of *saleable litharge*. It is used for various purposes, and particularly for glazing of earthen ware. The other part which remains is called *cold litharge*. It is remelted and reduced to lead. This fusion is called *cold fusion*, and the lead produced from it, called *cold lead*, is good and saleable, when the work has been well purified from the extraneous matters mentioned above. The tests impregnated with litharge are added to the same kind of ore when smelted ; because they contain not only much litharge, which may be reduced to lead, but also some silver, in all refinings, whether in great or in small, as Mr. Tillet observes.

When about two-thirds of the work are converted into litharge, no more of it is formed : the silver is then covered with a sort of white skin, which the refiners call *lightening* ; and they call the metal *lightened silver* or *finer silver*. The silver thus finer is not pure : every mark of it contains about four gros of lead : it is given to workmen, who complete the purification of it in the ordinary method, that is, by a second cupellation with a hotter fire ; which latter purification is called *refining*, and the persons who perform it are called *refiners*. The workmen employed in this first operation or *fining* give improperly the name *lightening* to the white skin formed on the surface of the silver, when brought only to a certain degree of fineness ; for we know that in essays the lightening or coruscation above-mentioned does not appear but when the silver is perfectly fine, or, at least, as fine as it can be made by cupellation.

A fining of sixty-four quintals of work of Ramelsberg yields about eight or ten marks of fine silver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of saleable litharge, from twenty-two to twenty-three of

cold litharge, from twenty to twenty-two quintals of tests, and six or seven quintals of dross. The operation lasts from sixteen to eighteen hours.

If the silver before these operations was alloyed with gold, it retains it still after the fining and refining. The gold, if the quantity be considerable enough, may be separated by parting. The operations for the purification of gold by cupellation are perfectly the same as those of silver. If the gold to be fined contains silver, this silver remains with it after the operation; because both these metals resist the action of lead. The silver may afterwards be separated by parting.

DLXXXIV. R E F R A C T O R Y. This word is applied to unfusible substances, or those which cannot be melted in a violent fire.

DLXXXV. R E F R I G E R A T O R Y. A refrigeratory is a copper vessel soldered round the capital of the alembic. Its use is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpose. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapors of the liquor which rise in distillation may be condensed more easily and more quickly. These refrigeratories were much used formerly, and all alembics were furnished with them: but modern distillers find that this vessel is not attended with the advantages formerly believed; for the distillation cannot succeed unless the capital of the alembic be as hot, or almost as hot, as the cucurbit. Mr. Beaumé observed, that when the capital was cooled by very cold water, the distillation is soon stopped, and does not again begin till the capital is considerably heated.

The refrigeratory has for these reasons been much neglected, and a *worm* substituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this respect, that it is adapted to the nose of the alembic, instead of surrounding the capital. See ALEMBIC, DISTILLATION, and WORM. See also PLATE I. Fig. 8.

DLXXXVI. R E G I S T E R. Registers are openings in different parts of furnaces, which are to be shut occasionally with stoppers of burnt clay. By means of registers we may govern the fire as we please; for by opening or shutting them properly we may not only encrease or diminish the activity of the fire, but also we may apply its action more to one part of the furnace than another, by giving direction to the current of air which passes thro' it. Notwithstanding the utility of registers, they are much neglected. Many chemists have disused registers, probably because they did not find the advantages from them which they expected. The reason of this is, that registers have hitherto been ill made. Their principal fault is, that they are generally too small. A register cannot have its proper effect unless it have an opening of two, three, or four inches, for a furnace, the internal diameter of which is a foot: but we frequently see furnaces of eighteen or twenty inches diameter, with registers, the openings of which are scarcely eight or ten lines. Besides, all those who use furnaces are far from understanding their construction. See FURNACE.

DLXXXVII R E G U L U S. The name *regulus* is given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who expecting always to find gold in the metal

metal collected at the bottom of their crucibles after fusion, called this metal thus collected, *regulus*, as containing gold, the king of metals. But although, since the cultivation of philosophical chemistry, these metallic masses composed of several metals mixed together are frequently called by this name, yet it is more particularly applied to certain semi-metals which have no proper name, such as the *regulus of antimony*, *regulus of arsenic*, and *regulus of cobalt*.

DLXXXVIII. R E G U L U S of A N T I M O N Y. *Regulus of antimony* is the semi-metallic substance contained in mineral antimony, after it has been separated by proper operations from the sulphur which mineralises it.

This semi-metal, when very pure and well-fused, is of a white shining color, and is composed of laminæ applied to each other. It is one of the metallic matters which most easily takes the regular arrangement of parts which is proper to it. When it has been well fused, and afterwards cooled not too hastily, and when its surface is not obliged to conform to the shape of any solid matter which touches it during the time of its hardening, its regular arrangement becomes sensible both externally and internally. This kind of crystallization forms then upon the upper surface of the *regulus of antimony* a sort of star, composed of many radii issuing from one center. Alchemists disposed to the marvellous, imagined this to be very mysterious and significative, and that it was nothing less than a star appearing to magi or sages to conduct them to the ~~palace~~ of the king. But this wonder has been reduced by Stahl in his *Opera Chemica*, and by Mr. Reaumur in a Memoir of 1724, to what it really is; that is, to the regular arrangement of the integrant parts of the *regulus of antimony*, when, by a perfect fusion and slow cooling, they have had time and opportunity to place themselves in that disposition to which they naturally tend from their primary form: and since that time, chemists have found that this phenomenon is common to all metallic matters, which form, in similar circumstances, not stars, because the integrant parts of each have peculiar shapes, but different figures no less regular and dependent on the form of these parts. It is an effect absolutely similar to the regularity of the figure of salts in their crystallization. See CRYSTALLIZATION.

*Regulus of antimony* is moderately hard, but, like the other semi-metals, it has no ductility, and breaks in small pieces under a hammer.

It loses  $\frac{1}{4}$  part of its weight in water. The action of the air and of water destroys its lustre, as it does to all imperfect metals, but it does not destroy and rust it so effectually as it does copper and iron.

This semi-metal is fusible with a moderate heat, and as soon as it begins to be red-hot: but when it is heated to a certain degree, it fumes continually, and is dissipated in vapors, because it is semi-volatile, like the other semi-metals.

The fumes of *regulus of antimony*, when passing through air, form what are called *argentine flowers of regulus of antimony*. They are nothing but the earth of this semi-metal deprived of part of its inflammable principle, and capable of being reduced to the state of *regulus* by its union with this principle. See FLOWERS (ARGENTINE).

This *regulus*, by calcination with a moderate fire, is deprived of more and more of its phlogiston, and is changed successively first into a grey calx capable of being fused by a stronger heat either into a vitreous and brittle matter, but  
brown

brown or opake, or to a reddish transparent glass, according to its degree of calcination. The former matter is a *liver of antimony*, and the latter a *glass of antimony*. See these words.

If the calcination be continued longer, the calx of the regulus of antimony loses more and more of its phlogiston, color, volatility, fusibility; and, lastly, may be rendered similar to the white calxes of antimony prepared by more expeditious processes, called *diaphoretic antimony*, and *bezoard mineral*.

Nitre detonates with this semi-metal, and accelerates more or less, according to the quantity of it employed, but always considerably, these calcinations, as it does with all the imperfect metals.

Mineral acids dissolve regulus of antimony very difficultly. Aqua regia is the best menstruum of it. Nevertheless a very good combination of the marine acid with this metallic matter may be made by the process for butter of antimony. Sulphur acts upon regulus of antimony, with which it forms a compound not different from mineral antimony. Liver of sulphur dissolves it effectually, and forms with it an *antimoniated liver of sulphur*, more or less alkaline, from which a kermes mineral and golden sulphur of antimony may be obtained.

We only slightly mention here these preparations of regulus of antimony. As they are made most commonly, and even most conveniently, with antimony, they are more particularly described under the article ANTIMONY, and under the articles of the several names by which they are known.

Regulus of antimony is seldom found within the earth in any other state than mineralised by sulphur, and in form of antimony. Mr. Anthony Swab mentions, in the Memoirs of the Swedish Accademy for 1748, that he had found, in a mine near Salberg in Sweden, a regulus of antimony not mineralised.

Regulus of antimony is easily obtained pure and disengaged from sulphur, by the ordinary process for obtaining metallic matters from their ores, that is, by calcining them, and thus depriving them of their mineralising substances, sulphur and arsenic, and afterwards by fusing the metallic earth with a matter proper to give it phlogiston. Thus, by fusing the grey calx of antimony, for instance, with black flux or soap, we shall obtain a fine regulus of antimony, as Kunckel has shewn, and as Mr. Geoffroy afterwards practised. But the ordinary method of making small quantities of the regulus in laboratories, and described in books of chemistry, is more expeditious, because calcination is avoided. It consists in mixing four parts of crude antimony with three parts of tartar and one part and a half of nitre; in detonating this mixture, by parts, in a large red-hot crucible; and afterwards by raising the heat so as to produce fusion. When the crucible is cold, it is to be broken, and at the bottom may be found a regulus of antimony lying under a saline scoria, from which it is easily separated by the stroke of a hammer, as has been said under the word *antimony*.

The nitre added in this operation consumes quickly the largest part of the sulphur of the antimony. The tartar is burnt and alkalisied. This alkali, mixed with a part of the alkali of the nitre, seizes a portion of the sulphur of antimony, with which it forms a liver of sulphur; and this liver dissolves in its turn a portion of the regulus of antimony, which consequently remains in the scoria. The scoria also contains a certain quantity of vitriolated tartar formed by the acid of the portion of sulphur, the phlogiston of which has been burnt during

during detonation, and by a part of the alkalis of nitre and of tartar. As tartar enters largely into this mixture, and as it contains much oil, a sufficient quantity of phlogiston remains (as the quantity of nitre used is but small) to reduce the earth of the antimony to a metallic state.

We may easily perceive that this fusion of the ore of regulus of antimony, with intention to separate from it the regulus, has no other advantage than that of being very expeditious, because the calcination, which is long, is avoided. But it does not procure all the metallic matter of the ore, since a part of it always is combined with the liver of sulphur in the scoria; and also as regulus of antimony is volatile, much of it is dissipated in fumes during the detonation. This method, therefore, which without this inconvenience would be well adapted for obtaining at once a metal from a crude ore, is evidently unfit for the purpose of essay, in which case, great care must always be taken that no liver of sulphur be formed during the operation. For this reason the ore must be deprived very accurately of all its sulphur by torrefaction before it is fused. Some chemists even avoid the use of alkaline fluxes, as the black and white fluxes, in fusions for essays of ores, because a small quantity of sulphur frequently adheres strongly to the ore, notwithstanding the calcination; and this method is certainly the safest and most accurate. But when the precise quantity of metal contained in the ore is not required, we may conveniently use this fusion of crude mineral with crude flux, as is usually done for the obtaining of regulus of antimony in chemical laboratories.

Regulus of antimony is one of the most important metallic matters, because it furnishes some very powerful remedies. When taken in substance, it is emetic and purgative, but is uncertain in its effects, because it only acts when it is dissolved, or corroded by the substances it meets in the *primæ viæ*, and because these solvents are very various, according to the nature of the aliments, and also to the variable state of the temperament. When the use of antimony was first introduced, small globules of the regulus were taken internally, which passed through the intestinal canal, and lastly were thrown out of the body along with the evacuations which they occasioned. As these globules or pills were neither diminished nor altered sensibly after these operations, and as they were capable of serving an indefinite number of times, they were called *perpetual pills*. Cups also were made of the regulus of antimony, in which wine being left, acquired a purgative quality; but as the wine dissolved more or less in proportion to the quantity of acid contained in it, and as wine is very various in this respect, hence the effects of this wine were not more certain than those of the perpetual pills. Since the discovery of better antimonial preparations, these ancient remedies have been neglected. Their uncertainty, and even the dangerous accidents which they frequently occasion, have undoubtedly contributed not a little to the opposition that many physicians, otherwise persons of merit, made for a long time to the use of antimony, when it was first introduced into medicine. The famous quarrels excited concerning antimony are well known. On both sides of this contest there were some reason and some error. They who rejected the use of antimony certainly erred in proscribing a substance capable of furnishing so excellent remedies; and the most zealous partisans of it were too extravagant in their praises, at a time when its qualities and the methods of preparing it were not well known, and

when

when the effects of the antimonials then administered were so uncertain and dangerous.

Regulus of antimony is also useful in many arts. It enters into the compositions for metallic speculums of telescopes, and for printing types.

According to Mr. Geoffroy's table of affinities, it unites with metals in the following order. Iron, copper, silver, and lead; and according to Mr. Gellert, with zinc, iron, copper, tin, lead, silver, bismuth, gold.

**DLXXXIX. REGULUS (MARTIAL) of ANTIMONY,**  
*or* **REGULUS of ANTIMONY PRECIPITATED by METALS.** Regulus of antimony has much less affinity with sulphur than most other metallic matters, as iron, copper, tin, lead, silver, and bismuth. Accordingly, when crude antimony is fused with a sufficient quantity of any of these metals, the reguline part may be separated from the sulphur. A true precipitation is then made by the dry way. As iron, of all metals, has most affinity with sulphur, it is preferable to any other for the separation of regulus of antimony by this precipitation.

The process used for that purpose consists in making some horseshoe-nails white-hot in a crucible (these nails being soft iron and easily fusible with sulphur), to which is to be added twice their weight of crude antimony, and in procuring by a strong heat a fusion of the whole, after having covered the crucible. The iron which unites with the sulphur of the antimony is by its means perfectly fused; and, being rendered lighter than the reguline part of the antimony then deprived of sulphur, rises to the upper part of the melted mass, while the regulus sinks to the bottom.

If the fusion has been complete, we shall find upon breaking the crucible, when cold, a fine regulus of antimony covered with a hard scoria, which is a combination of iron with the sulphur of antimony. The most essential point to be attended to in this operation is to give a sufficient heat for a perfect fusion; but as this heat must be very strong, most of the processes directed in books for the preparation of this regulus, order the addition of a quantity of nitre equal to a fifth part of the antimony employed, as soon as the fusion commences. This nitre detonates with the phlogiston of the substances contained in the mixture, its detonation makes it considerably more fluid, and this nitre, when alkalisied, mixing with the scoria, forms a liver of sulphur, which dissolves a portion of the metals, and makes the scoria more fluid by giving it a saline quality.

Lemery and many others direct, that the regulus should be afterwards fused thrice, and that in the first of these three fusions an eighth part of crude antimony, with the same quantity of nitre as in the former fusion, should be added, and the nitre only in the two latter fusions.

The crude antimony added in the second fusion is intended to carry off by means of its sulphur a part of the iron which may be united with the regulus, and the nitre which is to be added in each of the following fusions is intended to purify further the regulus from any remaining portion of sulphur. The intention then of all these preparations is only to obtain a pure regulus of antimony, which may be obtained otherwise much more easily. *See the preceding article.*

**DXC. REGULUS of ARSENIC.** This is white arsenic, to which the properties of a semi-metal have been given, by combining it properly with a sufficient quantity of phlogiston.

Regulus of arsenic may be made by several methods. The process anciently used for this purpose consisted in mixing four parts of arsenic with two parts of black flux, one part of borax, and one part of filings of iron, or of copper and quickly fusing the mixture in a crucible. When the operation is finished a regulus of arsenic will be found at the bottom of the crucible, of a white livid color, and considerably solid. The iron and copper employed in this process are not intended, as in the operation for the martial regulus of antimony, to precipitate the arsenic, and to separate it from sulphur or any other substance; for the white arsenic is pure, and nothing is to be taken from it, but, on the contrary, the inflammable principle is to be added to reduce it to a regulus. The true use of these metals in the present operation is to unite with the regulus of arsenic, to give it more body, and to prevent its entire dissipation in vapors. Hence the addition of iron, while it procures these advantages, has the inconveniency of altering the purity of the regulus: for the metallic substance obtained is a regulus of arsenic allayed with iron. It may, however, be purified from the iron by sublimation in a close vessel; by which operation the regulated arsenical part, which is very volatile, is sublimed to the top of the vessel, and is separated from the iron, which, being of a fixed nature, remains at the bottom. We are not, however, very certain that in this kind of rectification, the regulus of arsenic does not carry along with it a certain quantity of iron, for in general a volatile substance raises along with it, in sublimation, a part of any fixed matter with which it happened to be united.

Mr. Brandt proposes another method, which we believe is preferable to that described. He directs that white arsenic should be mixed with soap. Instead of the soap, olive oil may be used, which I have found to succeed well. The mixture is to be put into a retort or glass matrafs, and to be distilled or sublimed with a fire at first very moderate, and only sufficient to raise the oil. As the oils, which are not volatile, cannot be distilled but by a heat sufficient to burn and decompose them, the oil therefore which is mixed with the arsenic undergoes these alterations, and after having penetrated the arsenic thoroughly, is reduced to a coal. When no more oily vapors rise, we may then know that the oil is reduced to coal. Then the fire must be increased, and the metallised arsenic will be soon sublimed to the upper part of the vessel, in the inside of which it will form a metallic crust. When no more sublimes, the vessel is to be broken, and the adhering crust of regulus of arsenic is to be separated. The regulus obtained by this first operation is not generally perfect, or not entirely so, as a part of it is always overcharged with fuliginous matter, and another part has not enough of phlogiston, which latter part adheres to the inner surface of the crust, and forms grey or brown crystals. This sublimate must then be mixed with a less quantity of oil, and sublimed a second time like the first; and even, to obtain as good a regulus as may be made, a third sublimation in a close vessel, and without oil, is necessary. During this operation, the oil which rises is more fetid than any other empyreumatic oil, and is almost insupportable. This smell certainly proceeds from the arsenic, the smell of which is exceedingly strong and disagreeable, when it is heated.

Regulus of arsenic, made by the method I have described, and which I consider as the only one which is pure, has all the properties of a semi-metal. It has metallic gravity, opacity, and lustre. Its color is white, and lustrous; it tarnishes in the air, is very brittle, but much more volatile than any other semi-metal. It easily loses its inflammable principle, when sublimed in vessels into which the air has access; the sublimate having the appearance of grey flowers, which by repeated sublimations become entirely white, and similar to white crystalline arsenic.

When regulus of arsenic is heated quickly and strongly in open air, as under a muffle, it burns with a white or bluish flame, and dissipates in a thick fume, which has a very fetid smell, like that of garlic.

Regulus of arsenic may be combined with acids and most metals. As white arsenic also can unite with these substances, we refer to that article. We shall only observe here, that, according to Mr. Brandt, in the Swedish Memoirs, the regulus of arsenic cannot be united with mercury. Altho' the phenomena exhibited by white arsenic and regulus of arsenic in solutions and allays are probably the same, yet an accurate comparison of these would deserve notice, especially if the regulus employed were well made; for some difference must proceed from the greater or less quantity of phlogiston with which it is united. See ARSENIC.

**DXCI. R E G U L U S of C O B A L T.** Regulus of cobalt is a semi metal lately discovered, and not yet perfectly well known. It receives its name from cobalt, because it can only be extracted from the mineral properly so called.

The process by which this semi-metal is obtained is similar to those generally used for the extraction of metals from their ores. The cobalt must be thoroughly torrefied to deprive it of all the sulphur and arsenic it contains, and the un-metallic earthy and stoney matters must be separated by washing. The cobalt thus prepared is then to be mixed with double or triple its quantity of black flux, and a little decrepitated sea-salt, and must be fused either in a forge or in a hot furnace. For this ore is very difficult of fusion.

When the fusion has been well made, we find upon breaking the crucible, after it has cooled, a metallic regulus covered with a scoria of a deep blue color. The regulus is of a white metallic color. The surface of its fracture is close and small grained. This semi-metal is hard, but brittle. When the fusion has been well made, its surface appears to be carved with many convex threads which cross each other diversely. As almost all cobalts contain also bismuth, and even as much as of the regulus itself, this bismuth is reduced by the same operation, and precipitated in the same manner as the regulus of cobalt; for although these two metals are frequently mixed in the same mineral, they are, in cobalt, they are incapable of uniting together, and are always found distinct and separate from one another when they are melted together. At the bottom of the crucible then we find both regulus of cobalt and bismuth. The latter, having a greater specific gravity, is found under the former. They may be separated from each other by the blow of a hammer. Bismuth may be easily distinguished from the regulus of cobalt, not only from its position in the crucible, but also by the large shining facets which appear in its fracture, and which are very different from the close, ash-colored grain of regulus of cobalt.

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This semi-metal is more difficult of fusion than any other, is less easily calcinable, and much less volatile. Its calx is grey, and more or less brown, and when fused with vitrifiable matters, it changes into a beautiful blue glass called *smalt*. This calx then is one of those which preserve always a part of their inflammable principle. It is soluble in acids as the regulus is. This regulus is soluble in vitriolic, marine, nitrous acids, and in aqua regia, to all which it communicates colors. The solution in vitriolic acid is reddish; the solution in marine acid is of a fine bluish-green when hot, and its color is almost totally effaced when cold, but is easily recoverable by heating it, without being obliged to uncover the bottle containing it. This solution of the calx or regulus of cobalt is the basis of the sympathetic ink, for without marine acid this ink cannot be made. See INK (SYMPATHETIC).

All the solutions of regulus of cobalt may be precipitated by alkalis, and these precipitates are blue, which color they retain when vitrified with the strongest fire.

\* Not only sympathetic ink, but also regulus of cobalt, may be made from the *zaffre* commonly sold, which is nothing else than the calx of regulus of cobalt mixed with more or less pulverised flints. For this purpose we must separate as well as we can the powder of flints from it by washing, as Mr. Beaumé does, and then reduce it with black flux and sea-salt.

Regulus of cobalt seems incapable of uniting with sulphur, but it easily unites with liver of sulphur, and the union it forms is so intimate, that Mr. Beaumé could not separate these two substances, otherwise than by precipitation with an acid.

\* Many curious and interesting remarks are still to be discovered concerning this singular semi-metal, and we may hope to receive further information from the endeavors of chemists who have undertaken the examination of it. Mr. Beaumé particularly has made considerable experiments on this subject, part of which he communicates to the public in his Course of Chemistry. All the new remarks in this article are from him. We wish that this able chemist would publish the numerous experiments he has made on this subject. See COBALI, INK (SYMPATHETIC), AZURE, and SMALT.

DXCII. R E S I N. The name *resin*, in its most general sense might be applied to all solid or concrete oily substances, not only those particularly called *resins*, as *massick*, *sandarach*, *white pitch*, &c. but also to wax, butter, fat, &c. But these concrete oily matters differ so much from each other, that they ought to be more particularly distinguished.

First, we may observe, that every solid oily substance owes its consistence to a saline, and especially to an acid matter; for we know that a liquid oil may be rendered thick by the addition of an acid, in proportion to the quantity of acid, and intimacy of combination. We also know, that by decomposing concrete oils by distillation, we obtain a quantity of acid so much greater, or so much stronger, as this oil is thick or more solid; or at least, that the quantity of liquid oil obtained by this distillation is proportionable to the quantity of acid separated.

But all concrete oils may be naturally combined with a sufficient quantity of acid, to give it this consistence, in two manners; for either they have received originally from nature a sufficient quantity of acid, or else, being formed originally fluid, they have lost by evaporation the part which is the most thin, most volatile, and least charged with acid, or least perfectly combined with acid; by which the proportion of well combined acid is more and more increased in the portion which is not evaporated, and which is therefore rendered thicker.

According to this distinction, concrete oils are naturally divided into two classes, the former comprehending those which are always found in a solid state, as wax, butter, and the fat of animals, and the latter comprehending the thickened or consolidated residuums of oils, which, from a liquid state, have become concrete by the dissipation and evaporation of their most fluid part. This second class includes all concrete oils, to which the name of resins has been applied. The properties of all concrete oils of the former class shew incontestably that these oils, or oily concretions, are of the kind of oils which are most sweet, most unctuous, least inflammable, and least volatile. Accordingly, all these matters resemble each other essentially, and only differ from one another by their greater or less solidity: but the resins or concrete oils of the second class are very different from one another, some of them having a strong aromatic smell, and dissolving easily and entirely in spirit of wine, and others having little or no smell, at least when cold, and being totally insoluble in spirit of wine; such as *gum-copal*. These properties so different amongst substances, confounded under one general name, shew that the liquid oils whence they were formed were essentially different. The former resins ought to be considered as the residuums of essential oils and natural balsams, since they evidently retain the principal properties of these. The latter can only be the residuums of certain oils not volatile, insoluble in spirit of wine, but capable of becoming rancid, thick, and dry; as oil of linseed, hemp, nuts, &c. for these oils, kept a long time in a dry place, in open shallow vessels, become concrete, transparent, deprived of all smell, and insoluble in spirit of wine, like the resin called *gum-copal*. Natural resins of this latter class are much rarer than those of the former, because more vegetables have a superabundant essential oil than a superabundance of drying oil, which is not volatile; or, at least, this second kind of oil is less easily evaporable than the former.

Resinous matters have not been sufficiently examined. We might probably find many of them similar to copal, and also others, which, proceeding from the two kinds of oils above described, mixed and evaporated together, would partake at the same time of the two kinds of resins resulting from these, and would hold a similar relation to the two kinds of resins, which gum-resins hold to gums and resins. Amber and other solid bitumens, which also are oily concrete matters, insoluble in spirit of wine, and evidently of vegetable origin, are probably formed by oils not volatile, thickened and hardened by age, or by intimate combination with mineral acids.

Resins, being only thickened balsams, are collected, as these balsams are, upon trees and plants from which they have exuded. Several of them are obtained by art. Such is the *black pitch*, which is obtained by making it melt  
and

and exude, by means of heat, from firs, pines, and other trees of this kind, which contain large quantities of it. Such also are the resins of jalap, scammony, and turpeth, which are obtained for medicinal uses, by digesting the vegetables containing them previously well dried, in spirit of wine, from which they are afterwards separated by adding a large quantity of water.

Resins are employed for many purposes. The cheapest kinds are used for torches, and to cover the outsides of ships and boats. The fine, transparent resins compose varnishes. Many of them are employed medicinally; either externally, as, for instance, those which enter into the composition of ointments and plasters; or internally, as the resins of scammony, jalap, turpeth, which are purgative. Other resins, the smell of which is agreeable, as, for instance, benjamin and storax, are employed as perfumes. See the articles BAISAMS, BITUMENS, OILS, and GUM-RESINS. See also the Dictionary of Natural History for the particular detail of the different kinds of resins and their uses.

DXCIII. R E T O R T. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck to bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named *retorts*. The most capacious part of the retort is called its *belly*. Its upper part is called the *arch* or *roof* of the retort, and the bent part is the *neck*. See PLATE I. Fig. 1. and 2.

Retorts differ in form and materials: their bellies are generally round: some of them are oblong and shaped like a cucurbit: these are called *English retorts*. They are preferable for the distillation of matters which are subject to swell and to pass into the receiver before they be decomposed.

A retort which has a little hole pierced in its roof is called a *tubulated retort*. This hole must be capable of being exactly closed with a stopper of proper materials. Retorts of this kind are employed in distillations, where some matter must be introduced into the retort after the receiver is joined to it, as in the distillation of smoking marine acid, and in the operations for procuring the several kinds of *chylus*.

If the retort be well made, the above-mentioned inclination of its neck must be most favorable to distillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is also by this form brought too near the furnace. If the neck be too little inclined, the vapors or liquor, which rise in distillation can scarcely flow into the receiver from want of sufficient descent, and only circulate in the belly of the retort. Retorts, when too strait in their bending, are very faulty. This form must be an impediment to distillation: the passage therefore from the belly to the neck of the retort must be free and wide, and gradually diminishing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are used in chemical operations, of common glass, crystal-glass, stone-ware, iron. Retorts of glass are used for all operations which require a less heat than is sufficient for their fusion. Earthen retorts are necessary where great heat is requisite, as in the preparation of phosphorus. Iron retorts are not much used, as they can only serve for the distillation

lation of substances which cannot act upon this metal, and as these substances are few in number. They can seldom be employed but for the distillation of mercury and of animal matters.

DXCIV. REVERBERATORY. *See FURNACE.*

DXCV. REVIVIFICATION. *See REDUCTION.*

DXCVI. RHUBARB. (*n*)

DXCVII. RISIGAL. The same as REALGAR.

DXCVIII. ROASTING of ORES. *See SMELTING, of ORES.*

DXCIX. ROSEMARY. (*o*)

DC. RUBIN of ANTIMONY. This is a kind of liver of antimony, made with equal parts of nitre and crude antimony detonated together, to which is afterwards added an equal part of common salt; but as the addition of the salt is useless, the preparation is not now employed. It is also called *magnesia opalina*. *See ANTIMONY and LIVER of ANTIMONY.*

DCI. RUBY (ARSENICAL). This preparation is red realgar, to which, by fusion and cooling, a transparency is given which makes it resemble a ruby; in which respect only it differs from realgar. *See REALGAR.*

(*n*) RHUBARB. An ounce of Rhubarb, reduced into gross powder, yielded with highly rectified spirit of wine three drams of extract, and afterwards with water two drams, two scruples and a half: the residuum weighed two drams twelve grains. By applying water first to another ounce, five drams, two scruples and a half of extract were obtained, and of the residuum five grains only were soluble in spirit of wine. Rhubarb appears from these experiments to contain much more gummy or mucilaginous than resinous matter; and hence spirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of most other vegetables.

The yellow color of rhubarb is remarkably less destructible than many other vegetable yellows. Aqua fortis and other acids, which destroy the color of saffron, turmeric, &c. make no change in that of rhubarb, or at most render it only turbid. Volatile spirits heighten the color, and incline it to red. Fixed alkaline salts have this effect in a greater degree. Solutions of green vitriol and other chalybeate liquors, change the color of infusions of rhubarb to an inky blackness; a mark that this root is possessed of an astringent quality. The

spirituous extract does not purge, although the extract made by water after spirit does, as if its purgative quality resided chiefly in a combination of gummy and saline matter. *Neuman.*

(*a*) ROSEMARY. The only active principle in this plant is the essential oil. The gummy extract, divested of the oil, has no remarkable taste any more than smell. The resinous extract retains a considerable part of the flavor of the herb, and of the essential oil. Its fragrance is communicated by infusion or by distillation to spirit or to water. Vinous spirit, impregnated by distillation with the flavor of rosemary, is called *Rosemary-water*. The flowers of this plant contain little or no smell, and no oil could be collected from the distilled water. From forty-eight ounces of leaves, three scruples and half a scruple of oil were obtained by distillation. Tournefort observes, that some sorts of rosemary, which produce no flowers nor seed, and which have very hard shrubby stalks, and from which the oil is strongly like camphire, are capable of obtaining a large quantity of oil, without obtaining their oil a part of the plant is consumed. *Neuman.*

DCII. R U S T. This name is particularly applicable to the earth of iron decomposed by the action of water and of air; but it may be given to the earth of any other metal capable of such decomposition, as copper, and all other metallic matters, excepting the perfect metals. Thus verdegriſe might be called the rust of copper. The kind of *ceruſe* formed upon lead, expoſed to a humid air, may be called *rust of lead*, &c. See the articles of the ſeveral metalli-

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DCIII. **S A F F R E.** See ZAFFRE.

DCIV. **S A F F R O N.** (p).

DCV. **S A F F R O N of I R O N.** Chemists have given the name *saffron* to many preparations which have a yellow color, like that of saffron, and particularly to the earth or rust of iron which has that color.

As iron may be deprived of its phlogiston by the combined action of air and of water, by that of air and fire, and, lastly, by acids, different names have been given to saffrons of Mars, or ferruginous earths prepared by these several agents. The rust of iron made by humid air is called *martial saffron prepared with dew*, or *aperitive saffron of Mars*. Iron, dephlogisticated by vitriolic acid or sulphur, is also called *aperitive saffron of Mars*. Lastly, that which is reduced into a calx by the action of fire, is called *astringent saffron of Mars*. See, for the medicinal virtues of these preparations of iron, the articles **ETHIOPS MARTIAL** and **IRON**.

As the saffrons of iron acquire different shades of red and orange colors, which they preserve when melted with very fusible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glass, or imitations of precious stones.

(p) **SAFFRON.** Both water and spirit extract the color and virtue of saffron. The former liquor improves the smell and heightens the color, whilst the spirit seems rather to weaken both. By drying two ounces and a half of the best saffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding strong smell, but had not the appearance of oil.

This is the active part of the saffron, which disorders the head and senses. Six drams of extract were obtained from an ounce of dried saffron by means of water, and two drams and one scruple were obtained from another ounce by means of spirit. Rectified spirit acquired no smell or taste by distillation from dried saffron; but water being thus distilled acquired a strong smell. *Nelson.*

DCVI. **S A F F R O N** of **M E T A L S**. Saffron of metals is the metallic earth of antimony, half deprived of its sulphur and phlogiston by detonation of crude antimony with nitre, and afterwards well washed; or it is liver of antimony deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians. See **LIVER** of **ANTIMONY**, and **TARTAR** (EMETIC).

DCVII. **S A L M I A C**. This word is an abridgement used by some for sal ammoniac. See **AMMONIAC** (SAL).

DCVIII. **S A L T**. The word salt, which is synonymous with saline matter or saline substances, when taken in its most general sense, is of all chemical terms that which is applicable to the greatest number of individuals. In fact, the number of different bodies, which have what chemists call a saline character, or which possess the principal saline properties, is so great that they are very far from being all known, as we shall afterwards see.

The essential properties of all matter, which ought to be considered as saline, are, to affect the sense of taste, to be soluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt those of water and of pure earth.

If we attend a little to the principal properties of the several bodies which are considered as salts or saline substances, we shall easily find that they do not all possess in the same degree the essential saline qualities that we have described. We shall see that some salts possess these qualities in the highest degree, while in others they are so weak and indistinct, that in many of them they can scarcely be discovered; and this diminution of the saline properties is so considerable in many compound bodies, that we may affirm that the limits which separate saline matters from others that are not saline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other side, that the saline substances whose properties are most distinct and strong, such, for instance, as the mineral acids, have great power over many other substances which have not a saline property; to which, by being combined together, they communicate more or less of their saline properties; or rather with which they form compounds, in which the saline properties are more or less sensible. Since experience shews that these saline compounds may be decomposed, so that the substance, which is not saline, shall be separated in its former state from the saline matter, which also shall recover the saline properties in the same force which it had before this union, we may from thence conclude;

First, that among the infinite multitude of bodies in which we may perceive saline properties, a very great number are composed of a substance essentially saline, and of one or more other substances not saline.

Secondly, that we ought to distinguish well substances which essentially possess saline properties from those which, not possessing any such properties themselves, are only capable of receiving more or less of them by uniting with substances of the former kind.

Thirdly, as the number of matters not saline which are capable of acquiring a saline character, or rather of forming compounds more or less saline by their union with substances essentially saline, is very great, the number of these last

must be very small, in comparison of the number of compounds in which saline properties are perceptible.

To give some explanation of this extensive subject, we must begin by determining precisely what substances essentially saline are, and by assigning a character which can distinguish them from those, which, without containing any thing saline, may nevertheless make part of salts, by the union they are capable of contracting with the former. These characters are the following:

All those substances ought to be considered as essentially saline which have not only the characteristic properties of salts, as taste and perfect miscibility with water, in an eminent degree, but which also when disengaged can communicate these properties, at least in part, to other substances which have them not, by combining with these latter, from which, when afterwards separated, they resume their former state and peculiar saline characters.

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, must be considered as substances essentially saline. Each of these bodies has the properties we have mentioned. Some other substances have not the properties of acids or of alkalis very distinctly; but as they have the properties of salts in general, and are capable of acting as acids, and of communicating saline properties to the compounds into which they enter, they may therefore be considered as substances essentially saline. Such are *arsenic* and *sedative salt*.

But if we reflect a little on the particular properties of each of the substances which seem to be essentially saline, we shall observe that they do not all possess these properties in the same degree. How great the difference is in this respect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can scarcely be known to be substances of the same kind. The taste simply acidulous of cream of tartar, its state of constant crystallization and dryness, its little solubility in water, lastly, the weakness of the adhesion which it contracts with all the substances with which it can unite, cannot be compared with the strong and corrosive taste of vitriolic acid, with the activity of its seizing moisture, with the surprizing heat occasioned by its mixture with water, lastly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The slightest view of the other substances essentially saline is sufficient to show that they differ much from each other, particularly in their degree of strength; in a word, that they do not possess the saline properties in the same degree.

These are the considerations which have undoubtedly determined the greatest chemists, particularly Stahl, to believe that the number of substances truly and essentially saline is very small, and even that only one saline principle exists, which by the intimate union it is capable of contracting with several other substances, constitutes a certain number of matters which possess the saline properties in a degree sufficiently strong to preserve these properties more or less in their several combinations with other matters that are not saline, and to recover them entirely when separated from these combinations; so that as they do not themselves undergo any decomposition, and as they always appear again with the same properties after having been combined and separated, they seem to be simple matters, essentially saline, although they really are compounds of several



several bodies, not saline, united intimately with one only saline principle, which is universal and always the same.

According to this notion, which is grand and perfectly analogous to the plan which nature seems constantly to pursue in the different orders of compounds, the question is to discover which is the most simple of all saline substances, and is the principle of all others. The best, and perhaps the only, method of determining in a question of this nature, is to compare together the several saline substances, and to consider that as the most simple of all, which possesses the saline properties in the most eminent degree, and which also appears upon all occasions to be least susceptible of decomposition or alteration; for all chemistry shews us, that these are the characters of the most simple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the saline matters under this point of view, we shall soon easily discover that we must begin by excluding all the saline matters called *neutral salts*; for any of these salts may be decomposed by ordinary chemical operations; and these decompositions show that many of them are composed of two simpler saline substances, one of which is called *acid*, and the other *alkali*; also, acids and alkalis are not in general so easily altered as neutral salts. In the classes therefore of these two saline substances, we must search for that which is the most pure and simple of all.

If we continue this inquiry upon the same principles, and compare together the saline properties of the purest and strongest acids and alkalis, we shall easily be convinced that the saline properties are stronger and more distinct in acids than in alkalis, since the former are more active, more dissolving, more adhering to the bodies dissolved, more deliquescent, &c. and also, that in the several operations of chemistry, alkalis fixed and volatile appear to be more susceptible of alteration and decomposition than acids. Amongst acids, therefore, we must search for the strongest and simplest saline matter.

Lastly, when we examine in the same manner, and compare together all the substances which have the principal properties of acids, and which are called acids, we shall clearly perceive that those which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and susceptible of alteration than acids deprived of all oil, which we call mineral acids; amongst which, the vitriolic will be easily discovered to be the strongest and most unalterable, and consequently of all bodies which have saline properties, the purest, simplest, and the most sensibly and essentially a salt.

Such considerations have undoubtedly induced the most profound chemists, and especially the illustrious Stahl, to consider this acid as the purest and simplest of all saline matters; and indeed all who are capable of reflecting on the greatest and most important phenomena of chemistry, will consider this proposition as a demonstrated truth. But Stahl carries this notion still farther. From his writings, and the whole of his doctrine, we may infer, first, "That he considers the vitriolic acid as the only substance essentially saline; as the only saline principle, which, by uniting more or less intimately with other substances that are not saline, is capable of forming an innumerable multitude of the other saline matters which nature and art shew to us; and,

"secondly, that this saline principle is a secondary principle, composed only of the intimate union of two primary principles, *water* and *earth*."

Every true chemist will easily discover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by saline substances. But we must at the same time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its consistency with the principles of chemistry, and with many phenomena, yet it is not supported by a sufficient number of facts and experiments to ascertain its truth.

We might here examine what degree of probability ought to be granted to this theory of salts, but this could not be properly accomplished without entering into long details, and penetrating into the depths of chemistry; in a word, without making a full and compleat treatise, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is most essential to be known concerning this grand hypothesis. We may perceive at once, that the former of these propositions, upon which is founded the theory which we mentioned, cannot be demonstrated, unless it be previously proved that every saline matter, excepting pure vitriolic acid, is nothing but this same acid differently modified, the primary properties of which are more or less altered or disguised by the union contracted with other substances. But we confess, that chemists are not capable of proving decisively this opinion; which, however, will appear very probable from the following reflections.

First, of all saline matters known, none is so strong, so unalterable, so eminently possessed of saline properties, as *vitriolic acid*.

Secondly, amongst the other saline substances, those which appear most active, and most simple, as *nitrous* and *marine acids*, are at the same time those, whose properties most resemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteristic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we see in the volatile sulphureous acid. See ACID (VOLATILE SULPHUREOUS), and ACID (NITROUS): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters susceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of these matters.

Fourthly, the marine acid, altho' its principles are less known than those of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with spirit of wine, as vitriolic acid does, which it cannot do in its natural state; and when iron is dissolved in it, it seems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid seems not impossible. Having once distilled very pure vitriolic acid upon a considerable quantity of white arsenic, I was struck with a strong smell like that of marine acid, which was not either that of arsenic or of vitriolic acid; for this has no smell, when it is pure.

Fifthly, oily vegetable acids become so much stronger, and more similar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining

combining them with alkalis, earths, or metals, and afterwards by separating them from these substances, by distillation, and especially by frequently repeating these operations. They might perhaps be reduced to a pure vitriolic acid, by continuing sufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or still better with spirit of wine, acquire the characters of vegetable acids. We may see a remarkable instance of this in Mr. Pott's *Dissertation de Acido Nitri Vinoso*.

Sixthly, the properties of fixed alkalis seem to be very different from those of acids in general, and consequently of vitriolic acid. Yet if we consider that a large quantity of earth enters their composition; that much of it may be separated by repeated solutions and calcinations; and also that by depriving these saline substances of their earthy principle, they become less fixed, more deliquescent, and, in a word, more similar to vitriolic acid in this respect; we shall not think it improbable, that fixed alkalis owe their saline properties to a saline principle of the nature of vitriolic acid, but much disguised by the quantity of earth, and probably of inflammable principle, to which it is united in these combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in several distillations, seem to shew sufficiently that they are matters essentially saline, as fixed alkalis are, and that their volatility which distinguishes them proceeds from their containing a less quantity of earth, but more attenuated, and a portion of very subtle and volatile oil, which enters their composition.

Besides these principal facts, there are many others, too numerous to be even slightly mentioned here: they may be found scattered in the works of chemists, particularly of Stahl. But persons who would collect and compare all the experiments relating to this subject, ought to know, that many of them are not sufficiently ascertained, and that perhaps a greater number of them have not been sufficiently prosecuted, and are, properly speaking, only begun. We must even acknowledge, that many of those experiments which we have mentioned have not been sufficiently prosecuted. *See all the articles of acids and alkalis.*

The second fundamental proposition of the theory of salts, namely, "that the vitriolic acid is compounded of only the aqueous and earthy principles," is, like the first, supported by many facts which give it a degree of probability, but which do not amount to a complete demonstration. This proposition may be supported by the following considerations.

First, experience constantly shews, that the properties of compound bodies are always the result of those of the component parts of these bodies, or rather they are the properties of these component bodies modified by one another.

Thus, if a body be composed of two principles, one of which is fixed and the other volatile, it will have a less degree of fixity than the former, and a less volatility than the latter. If it be composed of two principles, one of which is specifically heavier than the other, its specific gravity will be greater than that of one of them, and less than that of the other. The same observation is applicable to all the other essential properties, excepting those which destroy each other, as, for instance, the tendency to combination, or the dissolving power; for these latter properties are weakened so much more in the compounds, as their principles are more strongly united, and in more just proportion.

We observe nevertheless, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts must be equal, which is the case in few or no compounds.

Belides, some particular circumstances in the manner in which the principles unite with one another, contribute more or less to alter the result of the combined properties; for instance, experience shews, that when several bodies, particularly metals, are united together, the specific gravities of which are well known, the alloy formed by such union has not the precise specific gravity which ought to result from the proportion of the alloyed substances; but that in some alloys it is greater, and in others less. But we are certain, on the other side, that these differences are too inconsiderable to prevent our distinguishing the properties of the principles in the compounds which they form, especially when they have very different properties.

These things being premised, when we examine well the properties of vitriolic acid, we shall easily find that they partake of the properties of the aqueous and of the earthy principles.

First, when this acid is as pure as we can have it, it is like the purest water and the purest vitrifiable earths, free from color or smell, and perfectly transparent.

Secondly, although we cannot deprive the vitriolic acid of all the water superabundant to its saline cohesion, and therefore its precise specific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much less heavy than any earthy substance.

Thirdly, this acid is much less fluid than any pure earth, since, however well it may be concentrated, it may always be entirely distilled; for which purpose, a much stronger degree of heat is requisite than for the distillation of pure water.

Fourthly, we do not know the degree of solidity of vitriolic acid, or the *adhesion of aggregation* which its integrant parts have one to another, because for this purpose the vitriolic acid ought to be deprived of all superabundant water; but if we judge of it by the solid consistence of this acid when highly concentrated, as we see from the vitriolic acid called *glacé*, the integrant parts of this acid seem susceptible of a much stronger adhesion than those of pure water, but much less than those of earth, as we see from the instances of hard stones.

Fifthly, the union which this acid contracts with water and with earth, shews that these substances enter into its composition: for we know that in general compounds are disposed to unite superabundantly with the principles which compose them. All these properties of vitriolic acid, which so sensibly partake, and much more than any other acid, of the properties of earth and of water, are sufficient to induce us to believe that it is composed of these two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corrosive taste. This property is sufficient to raise doubts, if we could not explain it from principles which seem certain and general, relating to the combination of bodies. We shall here summarily recapitulate them, although we have spoken of them in several articles

articles of this work, particularly at the words *AFFINITY*, *AGGREGATION*, *SOLUTION*, *COMPOSITION*, *GRAVITY*, *SATURATION*.

We observe then concerning the property now in question, that is, of taste in general, that it can only be considered as an irritation made upon the organs of taste by lapid bodies: and if we reflect attentively upon it, we shall be convinced that no substance that is not impressed by some impulse, can irritate or agitate our sensible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their dissolving power. According to this notion, the taste of bodies, or the impression made upon our sensible organs by their tendency to combination, or by their dissolving power, are the same property; and we see accordingly, that every solvent has a taste which is so much more strong, as its dissolving power is greater; that those whose taste is so violent that it amounts to acrimony, corrosion, and causticity, when applied to any other of the sensible parts of our body besides the organs of taste, excite in them itching and pain.

This being premised, the question is, how earth, in which we perceive no taste nor dissolving power, and water, which has but a very weak dissolving power, and little or no taste, should form by their combination a substance, such as the vitriolic acid is, powerfully corrosive and solvent?

To conceive this, let us consider first that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very small molecules, or the integrant and constituent parts of bodies, seems proportionable to the density or specific gravity of these parts. Thirdly, that this same force is limited in every integrant molecule of matter; that if we consider this force as not satisfied, and consequently as a simple tendency to combination, it is the greatest possible in an integrant molecule of matter perfectly insulated, or attached to nothing, and is the smallest possible, or none, when it is satisfied by its intimate combination with other parts capable of exhausting all its action; its tendency is then changed into adhesion.

Hence we may infer, that the integrant parts of the earthy principle have essentially, and, like all the other parts of matter, a force of tendency to union, or of cohesion in union, according to their condition; that as this earthy principle has a much more considerable density or specific gravity than all other simple bodies that we know, we may probably presume that its primary integrant molecules have a more considerable force of tendency to union, in the same proportion, than the integrant parts of other principles; that consequently when they cohere together, and form an aggregate, their aggregation must also be stronger and firmer than that of any other body. Accordingly we see that the purest earthy substances, whose parts are united and form masses, such as, for instance, the stones called vitrifiable, are the hardest bodies in nature. We are no less certain, that as the tendency of the parts of matter to unite is so much less evident as it is more exhausted and satisfied in the aggregation, the parts of the earthy principle being capable of exhausting mutually all their tendency to union, we may thence infer, that every sensible mass of pure earthy matter must appear deprived of any dissolving power, of taste, in a word, of tendency to union, from the firmness of its aggregation. But we may also infer, that when these primary integrant parts of the earthy principle are not united

united together in aggregation, then, resuming all the activity and tendency to union which are essential to them, they must be the strongest and most powerful of all solvents.

These being premised, if we suppose again, with Stahl and the best chemists, that in the combination of the saline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then easily conceive that the primary integrant parts of the water, having essentially much less tendency to combination than those of earth, the tendency of these latter to union will not be exhausted, but satisfied only partly, by their combination with the former, and that consequently a compound must result, the integrant parts of which will have a strong dissolving power, as vitriolic acid is.

We may see from hence how much mistaken chemists are, who, considering earth only in its aggregation, or rather not attending to this state, and not distinguishing it from that state in which the parts of this same earth are so separated from each other by the interposition of another body, that they cannot touch or cohere together, have considered the earthy principle as a substance without force or action, and have very improperly called that a *passive principle*, which of all others is the strongest, most active, and most powerful.

However this general theory of salts may conform with the most important phenomena of chemistry, we must acknowledge that it can only be proposed as a systematical opinion, till it be evidently demonstrated by the decisive means employed in chemical demonstrations, namely, by decomposition and recombination: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together these two principles, this theory would cease to be a system, and would become a demonstrated truth. But we must confess that this theory is less supported by experiment than by argument, from the many difficulties that are inevitable in such inquiries. For on one side, we know that the simpler bodies are, the more difficult is their decomposition; and on the other side, the stronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very simple, since it is a compound of the first order, it ought strongly to resist decomposition; and as the aggregation of pure earth is the firmest that we know, it cannot easily be made to enter as a principle into a new combination with water to form a saline matter. The following are the principal experiments which have been made relative to this subject.

First, we seem to be certain, from many proofs, that all saline substances, comprehending those that contain vitriolic acid, as vitriolated tartar, Glauber's salt, and other vitriolic salts, which are sufficiently fixed to support a perfect drying, or rather calcination, being alternately dissolved, dried, and calcined a number of times, are more and more diminished in quantity, and that earth and water are separated from them each operation. But alkaline salts appear to be still more susceptible than any other saline matter of this kind of decomposition.

Secondly, when nitre is burnt in close vessels, so that we may retain not only all that remains fixed after this burning, but also what exhales in vapors, as in the experiment of the cylinders of nitre, we have a proof which seems decisive, that

that the mineral acid of this salt, which is not very far from the simplicity of vitriolic acid, is totally decomposed and reduced into earth and water. For if we examine the fixed residuum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a superabundant earth, which is separable from it by solution and filtration. And if the liquor in the receiver, formed by the vapors condensed there, be examined, which ought to be nitrous acid, if this acid had not been destroyed, we find that, so far from being acid, it is only pure water, sometimes even charged with a little fixed alkali, which had been raised by the force of the detonation. Thus nitrous acid is made to disappear in this experiment, and in its place we find only earth and water. *See ACID (NITROUS), CLYSSUS of NITRE, DETONATION of NITRE, and NITRE.*

Thirdly, the phenomena of limestone, which by calcination and extinction in water acquires saline properties that it had not before, its attenuation by fire, and its combination with water; and also the experiment of Beccher, who asserts, that if a vitrifiable stone be alternately made red-hot and extinguished in water a number of times, it may be so attenuated, that it shall be like a saline gelatinous matter; these, I say, shew that saline matters are actually formed by the intimate combination of the very attenuated parts of earth with those of water. We find in the writings of Beccher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other observations and experiments tending to prove the same proposition; but we must confess that none of the experiments we have mentioned, excepting that of the decomposition of nitrous acid by burning, are absolutely decisive, principally because they have not been sufficiently repeated, or prosecuted, nor carefully enough examined in all their circumstances.

Such is the actual state of the best theory of saline substances hitherto given. However fine and probable it may seem, it requires to be further illustrated, and better proved, especially by experiments. They who love inquiries into the sublimest parts of chemistry cannot engage in a more interesting subject.

As substances essentially saline, and particularly those of their combinations which are called *salts*, are very numerous, we shall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of these saline matters. We shall see by this kind of view, that although many combinations are known, many also are not known, because they have never been made; and many others are known but imperfectly, because they have not been sufficiently examined.

Substances essentially saline are, acids, alkalis, and neutral salts with basis of alkali.

The simplest and strongest acids, called *mineral acids*, are, *vitriolic acid*, called also *universal acid*, or *saline principle*:

*Nitrous acid*, commonly called *spirit of nitre* or *aqua fortis*:

*Muriatic acid*, called also *spirit of salt*, and *acid of common salt*. *See all these articles.*

The acids less simple and less strong than the mineral acids are those which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or less attenuated. These are crystallized

essential acid salts, such as *tartar*, called *cream* or *crystals of tartar*, when it is purified. See TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itself not only oily, but also spiritous. See VINEGAR.

The *unfermented acids of sharp fruits and plants*, as the juice of *gooseberries*, *citrons*, *sorrel*, &c. These acids have not been examined.

The acids and acid spirit, obtained in the distillation of vegetables, of their extracts, essential salts, oils, balsams, and resins. As all these acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The acids obtained from animal substances are,

The acid obtained in the distillation of *ants*, *flies*, and other *insects*; and the acid obtained in the distillation of *butter* or of *fat*. These acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. See BUTTER and FAT.

*Phosphoric acid*, the origin and nature of which are not so well known that we can determine to what kingdom it belongs. See PHOSPHORUS of KUNCKEL, and SALT (FUSIBLE) of URINE.

*Alkalis* or *saline alkaline substances* are,

The *fixed alkali of common salt*, called also *mineral* or *fossil alkali*, *marine alkali*, *crystals* and *salt of soda*, because it is obtained by lixiviation and crystallization, from the ashes called *soda*.

*Vegetable*, or *common fixed alkali*. It is often called *salt of tartar*, or *alkali of tartar*, in the works of chemists, because the ashes of tartar furnish the largest quantity of it. Both these fixed alkalis are called *caustic fixed alkali*, when they have been altered by quicklime, or by metallic calxes. See ALKALI (FIXED).

*Volatile alkali*. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, so that it afterwards cannot be obtained in a solid or concrete form. See ALKALI (VOLATILE).

## NEUTRAL SALTS.

Formerly those only were called neutral salts which were composed of acids and alkalis united together to the point of saturation, so that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all substances with which they can so unite, that they lose entirely, or mostly, their acid qualities. Thus, for instance, when they are united with earthy or metallic substances. We shall enumerate these neutral salts, observing the order of the acids already enumerated.

### VITRIOLIC SALTS.

Vitriolic acid, combined with marine alkali, forms a salt known by the name of *Glauber's salt*, or *salt mirabile*.



With fixed vegetable alkali it forms a salt called *vitriolated tartar*, *sal de dupbas*, and *arcanum duplicatum*. See *these names*.

With volatile alkali, it forms an ammoniacal salt, called *vitriolic ammoniacal salt*, and *secret sal ammoniac of Glauber*. See AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic salts with basis of calcareous earth*, known by the general name of *selenites*. See *that word*.

With argillaceous earth, it forms a *vitriolic salt with basis of argillaceous earth*, called *alum*. See ALUM.

With metallic substances, it forms different *vitriolic salts with metallic bases*, to which we ought to give the general name of *vitriol*, together with the name of the particular metal subjoined. Thus;

With gold, a salt little or not known, which may be called *vitriol of gold*.

With silver, a salt but little known, *vitriol of silver*.

With copper, a salt known by the name of *vitriol of copper*, or *blue vitriol*.

Vitriols are in commerce more generally called *copperas*. Accordingly, this is called *blue copperas*. It is also sometimes named *cyprian vitriol*.

The same acid with iron forms *vitriol of iron*, called *green or martial vitriol*, or *green copperas*.

With tin, it forms a salt little known, a *vitriol of tin*.

With lead, a salt little known, a *vitriol of lead*.

With quicksilver or mercury, a salt not yet well known, a *vitriol of mercury*.

With regulus of antimony, a salt little known, a *vitriol of regulus of antimony*.

With bismuth, a salt little known, a *vitriol of bismuth*.

With zinc and calx or flowers of zinc, a *vitriol of zinc*, known by the name of *white vitriol*, *white copperas*, *vitriol of Goslar*.

With regulus of cobalt, a *vitriol of cobalt*, very little known. Mr. Beaumé has begun to examine it.

With regulus of arsenic and arsenic, a *vitriol of arsenic*, or *arsenical vitriol*, very little known. See *the articles ACID (VITRIOLIC) and VITRIOL*, and *those of the salina alkalis, earths, and metallic substances*.

## NITROUS SALTS.

Nitrous acid, combined with all the substances of which we have just mentioned the combinations with vitriolic acid, forms salts to which we may give the general names of *nitre* or *nitrous salt*, specifying each salt by the name of the substance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *salpêtre*.

With marine alkali, it forms *cube* or *quadrangular nitre*.

With volatile alkali, it forms an *ammoniacal salt*, or *ammoniacal nitre*.

With calcareous earths, it forms a salt with basis of calcareous earth,

With argillaceous earth, it forms a salt with basis of argillaceous earth, a kind of

With metallic substances, it forms different

With tin, it forms a salt little known,

With lead, it forms a salt little known, *lower nitre*, *lower crystals*, or *crystals of silver*.

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With

With copper, *nitre of copper*, or *cupreous nitre*.

With iron, *nitre of iron*, or *martial nitre*.

With tin, *nitre of tin*, unknown.

With lead, *nitre of lead*, or *crystals of lead*.

With mercury, *nitre of mercury*, *mercurial nitre*, *crystals of mercury*.

With regulus of antimony, *nitre of antimony*, unknown.

With bismuth, *nitre of bismuth*, *crystals of bismuth*.

With zinc, its calx and flowers, *nitre of zinc*, unknown.

With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.

With arsenic and its regulus, *nitre of arsenic*, or *arsenical nitre*, very little known. See NITRES (METALLIC), or with METALLIC BASES. See also the articles ACID (NITROUS), the articles of all the substances we have mentioned, and those of the nitrous salts which have particular names.

## MARINE SALTS, or simply, SALTS.

Marine acid forms with all these substances salts which may be called by the general name of *marine salts*, or simply *salts*, and specified by the names of their particular bases. Thus,

With marine alkali, it forms *common salt*, *kitchen salt*, *sea-salt*, when extracted from the sea, and *sal gem* when dug from the earth.

With fixed vegetable alkali, *common salt with basis of vegetable alkali*, called *febrifugal salt of Sylvius* improperly, because it is no more febrifugal than any other; and still more improperly called *regenerated sea-salt*, because it differs essentially from sea-salt by the nature of its basis.

With volatile alkali, it forms *sal ammoniac*, formerly *armoniac*, and by some chemists called *salmiac*.

With calcareous earths, a *salt with basis of calcareous earth*. As this salt is obtained in the decomposition of *sal ammoniac* by means of quicklime, or other calcareous earths, chemists have improperly called the salt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *salt with basis of argillaceous earth*, very little or not known.

With metallic substances, it forms *salts with metallic basis*, specified by the name of each base. Thus,

With gold, it forms a *salt of gold*, unknown.

With silver, it forms a *salt of silver*, known by the name of *marcasita*.

With copper, it forms a *salt of copper*, known by the name of *malachite*.

With iron, a *salt of iron*, as *martial salt*, *arsenical salt*, &c.

With tin, a *salt of tin*. This combination, like that of the marine acid with metallic matters, may be made by dissolving the metal in the acid: but it may be still better made by the action of the acid, with the assistance of heat, and by means of the metal intended to be formed, or of a substance, a combination already made of which the acid is more capable; which is always possible when the acid is more capable of combining with the metal than that of the metal already combined. This manner of forming salts is

lizable salt of tin, by dissolving this metal directly in marine acid in the usual manner: this salt is but little known. The same combination is made by decomposing corrosive sublimate by means of tin, and by distillation. Thus we may obtain a combination of tin with marine acid, one part of which passes with excess of acid in form of a very smoking liquor, called *smoking spirit of Libanius*; and the other part which does not smoke, and which contains a larger proportion of tin, is sublimed in a solid state, and is called *butter of tin*.

With lead, *salt of lead*, known also by the name *plumbum corneum*.

With mercury, *salt of mercury*. It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is separated from the nitrous acid by means of marine acid; *mercury corrosive sublimate*, or simply, *corrosive sublimate*, when it is actually sublimed, and with such proportions of mercury and acid, that a very corrosive salt results from them; *sweet mercury*, *sweet sublimate*, and *aquila alba*, when sublimed with an additional quantity of mercury by which its corrosive quality is blunted.

With regulus of antimony, it forms an *antimonial salt* by distillation. It is called *butter of antimony*.

With bismuth, it forms a *salt of bismuth*, not much examined.

With zinc, and its calx and flowers, a *salt of zinc*, little known.

With regulus of cobalt, a *salt of cobalt*, also little known.

With arsenic and its regulus, a *salt of arsenic*, or *butter of arsenic*, little known.

We may observe concerning all these combinations of marine acid with metallic matters, that as this acid is very elastic, and as it is capable of adhering strongly with these substances, it does accordingly carry along with it more or less of them in sublimations and distillations; which is the reason that these salts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by solution, or by distillation and sublimation, as we see from the numerous exhibited by corrosive metals, as tin and regulus of antimony. Although chemists, and still more, alchemists, have operated much on certain combinations of metallic substances with marine acid, much yet remains to be done to illustrate this subject.

We may also observe, that aqua regia, composed of nitrous and marine acids, which is in general a great solvent of metallic matters, must form with many of them mixed salts, some of which are perhaps of peculiar natures; but these combinations do not seem to have been examined, inasmuch as salts, no more than many others, as we may easily see from the present enumeration. For the author has not met with the name of the several *soluble salts* which we have mentioned in this enumeration.

## TARTAREOUS SALTS.

The salts produced from the combinations of the acid of tartar, or of tartaric acid, with metallic matters, as it is with the several substances mentioned in the preceding enumeration, are not all of them known, but they are in general called *soluble tartars*, because they are all more soluble in water than the acid of tartar itself.

The.

The combination of cream of tartar with fixed vegetable alkali forms a neutral crystallizable salt, called *soluble tartar*, *tartarised tartar*, and *vegetable salt*. See this latter word.

With marine alkali, it forms the salt known by the name of *salt of Saignette*, *sal polychrest*, *salt of Rochelle*.

With volatile alkali, a *soluble ammoniac tartar*, unknown.

With calcareous earths, *soluble tartars with basis of calcareous earth*, very little known, but which appear similar to the *soluble tartars with basis of fixed alkali*.

With argillaceous earths, *soluble tartars with basis of argillaceous earth*, unknown.

With metals, *soluble tartars with metallic basis*, *soluble tartars of gold*, of *silver*, &c. which are all unknown, excepting the *soluble tartars with basis of iron* and of *glass of antimony*. The former is deliquescent, and called, when liquid, *tartarised tincture of iron*, or of *Mars*; and when evaporated, *martial extract*. It ought to be called *soluble martial tartar*. See TARTAR (SOLUBLE), and the other names here mentioned. The second soluble tartar with metallic basis is called *emetic or stibiated tartar*. See TARTAR (EMETIC).

## ACETOUS SALTS

We shall give this name to all salts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliquescent salt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a crystallizable salt not much known, to which no name has been given. It may be called *acetous salt with basis of marine alkali*.

With volatile alkali, an *acetous ammoniacal salt*, imperfectly known, and named *spirit of Mindererus*.

With calcareous earths, several *acetous salts with calcareous basis*, very similar one to another, and susceptible of crystallizing, and forming beautiful *silky vegetations*, some of which are superficially known, and named *salt of chalk*, of *crabs eyes*, of *coral*, &c.

With argillaceous earths, an *acetous argillaceous salt*, unknown.

With metallic substances, an *acetous salt with metallic basis*, of *gold*, *silver*, &c. which are all unknown, excepting the three following.

With copper, an *acetous salt of copper*, known in chemistry by the names, *crystals of Venus*, or of *verdigris*, and in commerce and arts by the name *distilled*, or *crystallized verdigris*.

With lead, an *acetous salt of lead*, known by the name of *salt of sugar of lead*.

With mercury, an *acetous mercurial salt*, lately discovered, but little known.

## VEGETABLE SALTS

This general name may be given to all acetous salts, excepting the acid juices, concrete salts, and other acetous salts, which are not crystallizable.

substances capable of uniting with these acids; but none of these salts are yet known.

## VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the salts which might be formed with the acids obtained by the distillation of vegetable matters, which furnish acid spirits or concrete acids, and which might be called *vegetable empyreumatic salts*.

## ANIMAL EMPYREUMATIC SALTS.

By this name we may distinguish neutral salts composed with acids obtained from the distillation of animal matters, as the *acids of insects, of butter, and of fat*; but all these salts are perfectly unknown.

Although we have given the epithet *empyreumatic* to salts formed with vegetable and animal acids, obtained by distillation of these substances with a heat greater than that of boiling water, we do not mean to imply, that these salts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to these acids after distillation. On the contrary, these acids may be deprived entirely or partly of this oil by passing into combinations of neutral salts, as happens to volatile alkalis when transformed into ammoniacal salts; but in this case we should be better able to examine the nature of these acids, and the epithet *empyreumatic* would only refer to the manner of obtaining them, and would serve to distinguish them from those vegetable or animal salts, the acids of which have been obtained without distillation in a naked fire.

## PHOSPHORIC SALTS.

By this general name we mean all salts produced by combining the acid of *phosphorus of urine* with alkaline, earthy, and metallic substances, a small part of which salts is known even immediately.

With fixed vegetable alkalis this acid forms a *phosphoric salt*, a kind of *fusible salt of urine*.

With marine alkalis, it forms another *phosphoric salt*, or *fusible salt of urine*.

With vitriolic alkalis, it forms a *phosphoric salt*, called also *fusible salt of urine*.

With calcareous and argillaceous matters, *phosphoric, calcareous, and argillaceous salts*, are known.

With metallic substances, *phosphoric metallic salts of gold, silver, copper, &c.* are known.

Some of the salts, substances which have sensible acid properties, some substances which have no acid properties, and others without having these properties, do nevertheless

nevertheless act as acids in their combinations with all substances capable of uniting with true acids, of forming with these substances kinds of neutral salts, and even of communicating, like the acids properly so called, saline properties to those substances which have them not. These combinations are by general consent classed amongst neutral salts.

### BORAX, or SALTS of BORAX.

The sedative salt, combined with marine alkali, forms *ordinary borax*.

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic bases of gold, silver, &c.* unknown.

### ARSENICAL SALTS.

Arsenic forms, with fixed vegetable alkali, a neutral salt perfectly soluble in water, and crystallizable, called by Mr. Macquer, who first observed it, *neutral arsenical salt*, or simply *arsenical salt*. See ARSENIC, and SALT (NEUTRAL ARSENICAL).

With marine alkali, another arsenical salt, very like the former, but not much examined.

With volatile alkali, an *arsenical ammoniacal salt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arsenical salt*, unknown.

With metallic substances, arsenic is perhaps capable of forming *arsenical salts with metallic bases*, or combinations in which saline properties would be perceptible, if these combinations were made by decomposing nitrous salts with metallic bases by means of arsenic, or by precipitating metals dissolved in acids by means of a solution of neutral arsenical salt in water; but perhaps from thence nothing would be produced but combinations similar to the *arsenical minerals*. We are quite ignorant upon this subject.

Saline alkaline substances, besides the salts which they can form with acids, can also act upon earths and metals, with which they form saline compounds, and from which, when separated, they appear as before. Accordingly, these compounds may for this reason be ranked amongst salts, and general and particular denominations may be assigned to them, according to the principles which compose them, as, for example, *nitrous, nitric, sulphuric, phosphoric, vitreous, metallic*, as of *gold, silver, &c.* But these denominations have not been considered in this view, and have been bestowed upon the salts.

Lastly, acids, alkalis, and even neutral salts may be combined with oily substances, form compounds which may be considered as salts, and a name be given, as it ought to be, to every thing that is liquid and dissolved in water: but these compounds form in some measure a distinct class, and are distinguished by the name of *soaps*.

From this enumeration of saline compounds we may see how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extensive part of chemistry are nevertheless very necessary, and are fundamental and elementary. To make them successfully, nothing is requisite but accuracy, patience, and knowledge of the first principles of chemistry. Every intelligent person is capable of making them. For this purpose the acids, alkalis, earths and metals employed must be very pure, the saline compounds resulting from their union must be examined; their taste, solubility in water, crystallization, deliquescence, and the methods of decomposing them must be observed. These considerations are certainly sufficient to excite the zeal of persons who would contribute to the progress of chemistry.

We now proceed to treat summarily of the principal salts known by the name of salts, in an alphabetical order.

### ACID SALTS.

Some chemists, and particularly ancient chemists, have thus named the saline substances which we only call *acids*. See ACIDS. We may however continue this name, and apply it to some concrete saline substances, as *tartar*, salt of *ferret*, &c. and to several other essential salts, which seem to be intermediate betwixt the state of pure acids and of neutral salts.

### SALTS with BASES ALKALINE, EARTHY and METALLIC.

By these general denominations the several neutral salts are distinguished according to the nature of the basis, or substance with which the acid is combined. See the above enumeration of salts. See also the article NEUTRAL SALTS.

### SALT ALEM BROTH

This is a saline matter, composed of *corrosive sublimate* and of *sal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemists, especially the alchemists, have much employed as a powerful solvent of metals, and even of gold. We are certain that corrosive sublimate and sal ammoniac act powerfully one upon another, and combine together without being decomposed, from which is formed a saline compound of a singular nature, capable of acting very effectually upon metallic substances. But the alchemists, who made so much use of this famous solvent, were far from understanding clearly the operations in which they employed it. As alchemists loved pompous names, they called this compound *salt of art*, *salt of wisdom*, *salt of power*.



## ALKALINE SALTS.

This name is frequently given to saline alkaline substances, as *fixed alkali*, *vegetable* and *mineral*, *volatile alkali*. See *these words*.

## SALT of AMBER, or VOLATILE SALT of AMBER.

This is a saline, oily, concrete matter, obtained by sublimation, or even by crystallization, from amber. It is a kind of essential salt, which forms shining needle-like crystals, has the smell of rectified oil of amber, and is soluble in spirit of wine. It is used only medicinally, as an antispasmodic, with the same effect as the spirit and rectified oil of amber. See BITUMENS and SALTS (ESSENTIAL).

## AMMONIACAL SALTS.

By this name are distinguished all neutral salts composed of any acid saturated with volatile alkali. See AMMONIACAL SALTS; and SALTS (NEUTRAL).

## ARSENICAL SALTS.

See SALT (NEUTRAL ARSENICAL).

## COMMON SALT.

Common salt is a neutral perfect salt, composed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali*.

This salt, which is produced by nature, is more abundantly and universally diffused than any other. Immense mines or quarries of it are found within the earth, and it is then called *sea gem* or *marine salt*. The waters of all the sea, and many subterranean and mineral waters, contain it. From every vegetable or animal chemists can extract it.

The taste of common salt is agreeable and moderately strong. It is crystallizable, and is one of those the figure of whose crystals is most regular, most determinate, and least variable. The crystals of this salt are perfect, or nearly perfect cubes, for the hollow pyramids obtained in certain evaporations of salt waters are nothing but a heap of cutlaid crystals, arranged in that manner near each other, by means of evaporation.

Common salt is moderately soluble in water. Four parts of water are required to dissolve one part of salt, and hot or boiling water dissolves no more of it than cold water. For which reason it is only obtainable from sea-water.



water, and other waters impregnated with it, by a continued evaporation. See CRYSTALLIZATION.

Although common salt be very crystallizable, and exactly neutral, it very readily becomes moist when exposed to humid air. It must be preserved in very dry places.

This salt is susceptible of contracting a certain union with *common salt with calcareous basis*; for which reason all the salt obtained either from sea-water or salt fountains always contains a certain quantity of this salt with earthy basis. Thus, if any common salt be dissolved in very pure water, and fixed alkali be added to this solution, we soon see the white earth of the salt with earthy basis which is precipitated. As therefore crystallization seems insufficient for the purification of common salt from the salt with earthy basis, when we would obtain a very pure common salt, as is necessary for some delicate operations, we must dissolve it in water, filtrate it, and add to it a solution of crystals of soda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we shall obtain a common salt perfectly pure. (g)

Common salt exposed to the action of fire, crackles and decrepitates pretty strongly, when heated to a certain degree, especially if it be heated hastily. Its crystals burst into small pieces during this decrepitation. This effect is produced by the water of the crystallization of the salt, which being confined by the parts of the salt, and at the same time reduced into vapors by the action of fire, bursts the parts of the salt, and is dissipated. Many chemists consider this decrepitation of common salt as a property peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other salts, are susceptible of a similar decrepitation.

If salt be exposed to a red-heat after this decrepitation, it fuses; and when afterwards cooled, it fixes in form of a white and almost opaque mass; but excepting that it has lost the water of its crystallization, it is the same as before this exposure to fire.

Several chemists, having observed that when common salt is heated in a retort, a little marine acid exhales from it while it contains any moisture, and that by adding more moisture, more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this small quantity of acid obtained by repeated humectations and distillations proceeded only from the common salt with earthy basis, which, we have observed, is always mixed with common salt. From this

(g) Sea-water contains dissolved in it not only sea-salt, or a combination of marine acid with mineral alkali, but also other salts, especially combinations of marine acid vitriolic acids with the earth called magnesia, which is not calcareous. Some of these salts, with water of magnesia, are crystallized along with the sea-salt by the evaporation of the sea-water, and part of them remain in the residuous liquor called the mother-water. Some portion of true calcareous earth, dissolved by marine and vitriolic acids, is said also to be contained in sea-water; but the quantity of this is very small in comparison of the quantity of magnesia; to the precipitation of which, therefore, the cloud or turbid appearance given to sea-water or to a solution of common salt in water, is chiefly owing.

earthy salt a portion of acid may actually be obtained by this method: but Mr. Beaumé has found, that no acid can be thus expelled from common salt, perfectly purified in the above-mentioned manner.

This salt is absolutely unalterable by fire, even when it has been heated strongly, together with inflammable matters. The unalterable property of common salt by fire proceeds from the small disposition which its acid has to combine with phlogiston. This truth has been demonstrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this salt be fixed in the fire to a certain degree, yet when it is exposed to a violent fire with free access of air, it exhales in vapors, and attaches itself in white flowers to bodies which it finds less hot than itself. We have examples of this effect in certain fusions of ores, where common salt is added; and in glass-house furnaces, where this salt, of which a certain quantity is contained in soda and potash, and which cannot enter into vitrification, attaches itself to the sides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and sedative salt, which can decompose common salt by disengaging its acid: for arsenic, which so easily and effectually decomposes nitre, cannot act upon this salt; a phenomenon, the cause of which deserves to be examined, and which is certainly connected with an important theory.

Common salt is of all saline substances the most necessary, and extensively useful. Besides the particular uses of its acid and alkali in many chemical operations and in arts; besides its great utility in the fusion of glass, which it whitens and purifies, although it does not enter, and perhaps because it does not enter into their combination, as Mr. d'Antic has shewn; and from the property it has of facilitating the fusion and precipitation of the metallic parts of minerals in essays, and of covering them perfectly; besides these, I say, its great use in aliments, the taste of which it improves by its agreeable piquancy, when mixed in proper quantity, is universally known. But this is not the only advantage; for it retards and prevents the putrefaction of almost all our aliments, without producing any such change upon them, even when preserved a long time by means of it, as to render them unfit for the purpose of nourishment. All other saline matters may indeed preserve from putrefaction, as common salt does, and some of them even more effectually: but we do not know any other, the taste of which renders it capable of being substituted to common salt for this purpose.

A very remarkable circumstance in the antiseptic property of common salt, and of some other salts, is, that this property varies surprisingly according to the proportions in which the salt is employed: for the salt, mixed with animal matters in a large proportion, preserves them from putrefaction, which it accelerates considerably when a small quantity only of it is employed. This singular fact is proved by the experiments of Messrs. Pringle and Macbride, and particularly by those of the accurate and intelligent author of an *Essay towards a History of Putrefaction*, Mr. Gardane, Physician to the Faculty of Paris, who, having convinced himself of this fact by his own experiments, mentioned it in a very good thesis, and has drawn from it a conclusion which seems to me very just, namely, that small quantities of common salt, such as those taken with aliments, facilitate digestion, which he considers as a beginning

putrefaction.

putrefaction. If this opinion be as true as it is probable and consistent with the principles of chemistry, and of the animal economy, then common salt is not only agreeable and useful, but also salutary, at least to all constitutions in which the digestion is too remote from putrefaction, as in those which are properly called *crudities*: for we cannot but agree, that different temperaments differ much in this respect. See the articles ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER of SALT FOUNTAINS, SALTS, and SALTS (NEUTRAL).

## CRYSTALLIZABLE SALTS.

By this name we distinguish all saline matters susceptible of crystallization. It is contrary to that of *fluor salts*, by which are distinguished saline substances that cannot be obtained in a crystallized concrete form, such as nitrous and marine acids, volatile alkali altered by quicklime, and some others. We have nevertheless reason to believe, that, rigorously speaking, every saline substance is essentially susceptible of crystallization, and that in this respect they only differ in the degree of facility with which they may be crystallized; for we are certain that many very deliquescent salts, the crystallization of which has not, that I know of, been ever observed, such as *common salt with calcareous basis*, may nevertheless assume solid regular forms by the cooling of their solutions when very much concentrated. Mr. Beaumé has observed the crystallization of this and several similar salts. See CRYSTALLISATION, DELIQUESCENT, SALT, and SALTS (NEUTRAL).

## SALTS of CENTAURY, of WORMWOOD, of SORREL, &c.

The name of *salt*, added to the proper name of some substance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the ashes of vegetable matters. Salts of wormwood, centaury, &c. are saline matters obtained by lixiviating the ashes of these plants: but these names are improper in several respects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is useless to distinguish them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is so predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names, *salt of tartar*, *salt of soda*, which are frequently given to the alkalis of these substances, are for the same reason very improper. They ought to be called *alkali of tartar* and *alkali of soda*.

Certain concrete acids, as the essential salt of sorrel, tartar, &c. are also simply called *salt of sorrel*, &c. This is also faulty, because these names do not denote the nature of the saline matters, and may be the occasion of confounding them with other salts of a very different nature. They ought to be named *acid salt of tartar*, *acid salt of sorrel*, &c.

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The names *salts of coral*, of *pearls*, of *crabs eyes*, are not more accurate unless we add the epithet *acetous*, as *acetous salt of coral*, &c. for these substances may be combined, and may form salts with any other acid, as well as with vinegar.

Let us now judge if the names, *salt of quinquina*, of *sena*, of *union*, &c. given to the dry extracts of these matters made in the manner of the Count de la Garaye, are not entirely improper. See the preceding enumeration of salts.

### SALT of COLCOTHAR.

This is a white saline matter, obtained by lixiviating colcothar. This matter is not much used, and has not been much examined. It is probably some *felenitic* or *aluminous* substance, which is mixed with the vitriol, and which was contained in the pyrites from which the vitriol was extracted.

### SAL DE DUOBUS.

It is a neutral salt, formed by saturating vitriolic acid with the alkali of nitre. See TARTAR (VITRIOLATED).

### DELIQUESCENT SALTS.

Thus are named all saline matters which may be obtained by crystallization or drying in a concrete form, but which, when exposed to air, imbibe its moisture, and lose their concrete crystallized form, deliquiating into a liquor by means of this moisture. See DELIQUESCENCE.

### SALTS of ENGLAND, of EPSOM, of SEDLITZ.

Some saline substances have been denominated from the countries where they have been first discovered. Thus a very rectified concrete volatile alkali, obtained from silk, is called *salt of England*; and even some druggists give this name to the concrete volatile alkali obtained from sal ammoniac.

In a similar manner, the name of *Epsom salt* is given to a badly crystallized, bitter Glauber's salt, which easily becomes moist, because it is mixed with common salt, and common salt with calcareous salts. It was first obtained from a salt well at Epsom near London. This name has been since given to a similar Glauber's salt obtained from salt-marshes in France, and also to a true and pure Glauber's salt obtained from the *stale* of the salt-works of Aachen and Franche-compe, the crystallization of which they almost purposely prevent it from resembling entirely the pure salt of Glauber.

*Salt of Sedlitz* is also a Glauber's salt under another name, and perhaps the same may be said of many other salts denominated from places.

ESSSEN.

## E S S E N T I A L S A L T S.

This name is given to all concrete saline matters which preserve the smell, taste, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The usual method of preparing them is by evaporating, to almost the consistence of a syrup, the liquors containing the essential salt, namely, the expressed and depurated juices and strong decoctions, and by keeping them in a cold place. From many of these liquors, saline matters or crystals are deposited upon the sides of the containing vessels after a considerable time, and after they have undergone a kind of fermentation. These crystals, which are always very red, may be purified by dissolving them in water, filtrating, evaporating, and crystallizing.

We may observe, that the salts thus obtained from animal and vegetable matters are sometimes nothing but vitriolated tartar, Glauber's salt, nitre, common salt, and other such neutral salts, which ought not to be considered as the essential salts of the substances from which they are extracted.

These mineral salts are extraneous to the vegetables and animals from which they are obtained. They are not parts of those substances, nor are combined with them; and when they are purified from the extractive matter with which they are at first only mixed and covered over, they have then nothing vegetable or animal. These salts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their vessels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, because they are naturally incapable of such union.

\* The proof of this truth is, that they are always obtained from vegetables and animals in the same state in which they were introduced, and that their quantity in these substances is altogether unconstant and variable, without any real difference being produced in the vegetables or animals by this variation of the quantity of these salts. Certain plants, as the *parietaria*, but still more the *corona solis*, have the property of imbibing so much nitre, that, when they grow in nitrous soils, they are almost filled with this salt. I have seen the dried pith of *corona solis* so full of crystallized nitre, that when shook over a paper, a considerable quantity of good deslagrating nitre might be collected. But we know also that this plant, when cultivated in a less nitrous soil, does not contain nearly the same quantity of nitre, although it be otherwise in good condition. These mineral salts therefore must not be considered as the essential salts of plants or animals, and only those salts are to be considered as such, in the combination of which we find oily parts, which cannot be separated from them, unless the salt be decomposed.

In the second place we shall observe, concerning salts truly called essential, that but very few of them are yet known, and most of these but very imperfectly. Of all these essential salts the best known is tartar, the properties of which may be seen under the name Tartar. The druggists have a very white concrete salt, well crystallized, and soluble in water, which they call *salt of ferrel*. We may indeed prepare from the juice of ferrel, by the above-mentioned process, an essential and concrete salt, but much more earthy and less acid  
that

than the salt above-mentioned. Besides, Mr. Braumé, who has made some inquiries into this matter, affirms, that a true salt of sorrel could not be procured at the price of the salt which is commonly sold under that name, the quantity of salt obtainable from sorrel being very small. The salt above-mentioned is brought from Germany, is much more acid and more soluble in water than cream of tartar; it acts upon all substances soluble by acids; but the neutral salts thence formed have not been examined.

*Flowers of benjamin, volatile salt of amber,* and other saline matters of the same kind, seem to belong to this class of essential salts; but they are little known. Essential salts may be considered as a new subject of inquiry.

## F I X E D S A L T S.

Many chemists give this name to the salts obtained from the ashes of plants, which not having been dissipated by fire, ought to be considered as fixed, in comparison of the other saline matters of these plants, which evaporate during their deflagration.

As the saline substances remaining in the ashes of vegetables are entirely or chiefly alkaline, the name of *fixed salt* has become synonymous with that of *fixed alkali*. But other saline substances, as most neutral salts, which have not bases of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any saline matter is not perfect; since any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glass-houses. A part of the fixed alkali, of the common salt, of Glauber's salt, of vitriolated tartar, and other equally fixed salts, contained in the ashes used in the composition of glass, are perpetually exhaling, during the fusion of glass, in a vapor which may be seen above the pots; and this vapor forms saline incrustations round the openings and other least hot places of the furnace. Accordingly, the quantity of salt of glass which covers the surface of the melted glass is continually diminishing. I have had occasion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the same composition for crystal-glass, of which soda and pot-ash made paste. The crucibles first taken out were covered with a crust of salt of glass more than two lines thick; those taken out 18 or 20 hours afterwards had only a very thin stratum of glass-gall; and, lastly, the crucibles which remained 72 hours in the fire, had no salt, or only a very small quantity, upon the middle of the surface of glass.

Hence we ought to conclude that the quality of fixity ascribed to some salts is only relative. We consider those as fixed, which, when exposed during several hours, without any sensible diminution. Salts which, by the continued heat, are reduced into vapors and sublimed, are called *volatile salts*, or *essential salts*, and *corrosive sublimes*; and lastly, those which are dissipated without heat, or with very little heat, as the *volatile acids* and *alkalis*, are called *volatile salts*.

## F L U O R S A L T S.

This name is given to all saline substances which cannot by any method be rendered solid; such are nitrous and marine acids, volatile alkali altered by quicklime, and some others. This quality depends on their volatility, and on the affinity which they have with water superabundant to their saline essence. In this latter point they resemble deliquescent salts, and they may even be considered as salts perpetually, and unfurmountably deliquescent. But they differ from salts that are only deliquescent, in this circumstance, that these latter are much less volatile than the fluor salts, and can support a heat sufficient to deprive them of all their superabundant water, and to reduce them to a concrete form. See DELIQUESCENT and SALT.

## F U S I B L E S A L T of U R I N E.

This salt, called also *native or essential salt of urine, phosphoric salt, microcosmic salt*, is a neutral salt composed of an acid named *phosphoric*, saturated with an alkali fixed or volatile; for both these kind of alkalis seem to be contained in urine.

To obtain this salt, urine fresh or putrid is to be evaporated to the consistence of a syrup, slowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fusible salt crystallizes on the sides of the vessel. When the salt ceases to form itself on the vessel, the liquor is to be decanted, and again evaporated, that still more crystals may be obtained by the same method. These crystals are to be collected, which are very dirty and brown. They may be purified by dissolving in pure water, filtering, evaporating, and crystallizing, according to the general method. These operations ought to be repeated when the salt is required to be very white and pure. Thus they are disengaged not only from the extractive part of the urine which discolors them, but also from a portion of common salt which may be mixed with them, particularly when the urine has been much evaporated.

This salt is very susceptible of crystallization, and is one of those which are more apt to crystallize by cold, than by evaporation.

If this salt be exposed to the action of fire in close vessels, a very pungent volatile alkali is expelled from it, which Mr. Schloffer has observed to be always fluor, like that which has been altered by quicklime. This chemist affirms even that if concrete volatile alkali be combined with the fusible salt of urine, and separated from this salt by distillation, it will be in a fluor state.

The acid of this salt is fixed, and remains at the bottom of the vessels, melted to a viscous matter, if the heat has been sufficient for that purpose. This is the acid which produces the phosphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteristic properties to the fusible salt of urine. See the properties of this acid under the article PHOSPHORUS of Kunckel.

If this fusible salt be mixed with the other fusible salt with basis of fixed alkali, as this latter salt cannot be decomposed merely by distillation, nor even by means of phlogiston, phosphorus is therefore chiefly produced from the former, or the ammoniacal fusible salt. See PHOSPHORUS and URINE.

## F O S S I L S A L T S.

Thus are called all the salts obtained ready formed within the earth; but more particularly common salt, which is coagulated in large masses within the earth, more frequently called *sal gem*.

## S A L G E M.

Sal gem is fossil common salt, of which is found within the earth in large masses. It has some transparency, by which it resembles crystal a little; and hence it has been called *sal gem*. The most considerable mines of this salt are in Poland. Very curious and interesting particulars concerning these mines may be seen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

## S A L T of G L A S S.

This matter, called also *glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and are collected together upon its surface, because they are specifically lighter. Hence we see, that as all the soda and potash employed for the composition of glass contain more or less of these extraneous neutral salts, the salt of glass must vary according to the saline substances employed. For the same reason no salt of glass is found where only pure and vitrifiable salts, as purified alkalis, nitre, borax, &c. are employed. See VITRIFICATION.

## G L A U B E R ' S S A L T.

The salt thus named, from the chemist who discovered it, is a neutral salt, composed of vitriolic acid saturated with marine alkali.

Glauber discovered this salt, while he was decomposing common salt by means of vitriolic acid, to obtain the smoking marine acid by distillation. The residuum of this distillation he found to be a saline mass, not crystallized, which he dissolved in water, and obtained, by evaporation and cold, transparent crystals. Glauber, surprised with the appearance and properties of these crystals, gave them



them the name of *sal mirabile*, by which they are still known, but more generally by that of *Glauber's salt*.

This salt, although composed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter salt in many respects, which differences are to be attributed to the difference of the alkaline bases, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taste of Glauber's salt is saltish but disagreeable and bitter. It is one of the salts which form the finest crystals. When large quantities of this salt are crystallized, and with due attention, large, oblong, columnar crystals are formed, the surfaces of which are striated longitudinally, like those of nitre.

The crystals of this salt are as transparent as ice, but when exposed to a dry air they lose their transparency by the evaporation of the water of their crystallization. Their surface, and afterwards the whole of the saline mass, is reduced by the dissipation of this water to a white saline powder. This change also happens to the crystals of marine alkali, to which probably this property of Glauber's salt must be attributed.

The quantity of water which enters into the crystallization of Glauber's salt is very considerable, and amounts to nearly one half of its weight. To this large quantity of water is probably owing the size and transparency of the crystals: For it seems to be a general rule, that the more water is contained in any salt, the more large and transparent its crystals are. From this same abundance of water, Glauber's salt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and solid, and requires greater degree of heat to fuse it.

This salt, although very soluble, even in cold water, is one of those which may be dissolved in a less quantity of boiling than of cold water. Hot water dissolves nearly an equal weight of it. From this property we may know, that the crystallization of Glauber's salt is best procured by the cooling of a sufficiently evaporated solution. Accordingly, a sure method of obtaining the finest crystals of salt of Glauber is, to evaporate the water, in which it is dissolved, till we find by taking out and trying a small quantity of the solution while evaporating, that crystals are pretty quickly formed by cooling. It is then to be poured into flat and shallow vessels, and cooled slowly. The larger the quantity of liquor is operated upon at a time, the larger will the crystals be; so that they may be obtained several feet long, and proportionably thick. These crystals are placed horizontally upon each other, and the crystallization ought therefore to be performed in wide vessels. *See CRYSTALLIZATION.*

Glauber's salt cannot be directly decomposed but by means of phlogiston only. For the decompositions made of it by metallic solutions are by means of a double affinity: and the decomposition which may be effected by the nitrous acid alone, upon Glauber's salt and vitriolated tartar, as Mr. Beaumé discovered, is also caused by phlogiston.

(c) The singular decomposition of vitriolated tartar, and of Glauber's salt, by means of nitrous acid, as mentioned by Mr. Beaumé, does not seem to be caused by the phlogiston of the nitrous acid, as the author of the Dic-

tionary believes; for Mr. Margraaf affirms, that these neutral salts, and also that nitre, may be decomposed in a similar manner by marine acid.

Glauber's salt is used only in Medicine. In small doses, as from one to two gros, it is resolvent and aperitive, and as such is added to pituita and apozems. It is also employed as an attenuant and corrective in the same dose in purgative potions; and it is itself a good and mild purgative, as all the neutral salts are, the basis of which are fixed alkali. The dose of this salt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's salt, we need not combine the pure disengaged vitriolic acid with the alkali of soda, nor decompose common salt by vitriolic acid, as Glauber did, unless we desire to obtain at the same time the marine acid. Nature furnishes a large quantity of this salt ready formed. A considerable quantity of it is contained in mineral waters, and perhaps all waters which contain common salt contain also some Glauber's salt. (1) The salt wells of Lorraine, of Franche-comté, of Epsom, contain much of it, and from these it may be easily obtained by crystallization. Further, from all vitriolic salts with earthy or metallic bases, as selenites, alums, vitriols, Glauber's salt may be obtained by decomposing them with soda. Lastly, by burning sulphur with common salt or soda, this salt may be formed. If it were much wanted, it might be easily and cheaply made by these processes. See the articles ACID (VITRIOLIC), ALKALI (MARINE), CRYSTALLIZATION, WATER of the SEA, and of SALT FOUNTAINS, SALT, and NEUTRAL SALTS.

### S A L T of L E A D:

Thus is commonly called the neutral salt composed of the acid of vinegar saturated with lead. As this salt has a sweet and saccharine taste, it is called *sugar of lead*.

To make this acetous salt, ceruss, which is lead half dissolved, and corroded by vinegar, is to be entirely dissolved in distilled vinegar by means of heat in a sand-bath; the liquor, when perfectly saturated, is to be evaporated, and crystallized by cooling, and many small needle-like crystals will be formed in it, which are to be well drained.

This salt is not much used in medicine. It is used only externally, because the lead is pernicious. It is employed in some arts, and especially in dyeing, to heighten the red color of madder. See CERUSS, LEAD, and VINEGAR.

(1) Glauber's salt, that is, a salt formed by vitriolic acid combined with mineral alkali, is contained in sea-water and in many mineral waters. But the *sal catharticus marinus* of the London Dispensatory, extracted from the bitter liquor remaining after crystallization of sea-salt in sea-water, and the salt of Epsom, and of most purging waters, tho' very similar in appearance to the former, is not Glauber's salt, with which it is frequently confounded, is found to be composed of vitriolic acid united with the earth called magnesia. See magnesia. This salt is of prismatic crystals like those of Glauber's salt, has a bitter taste, is less than an equal weight of water exposed to a moderate heat it dissolves, and loses the water of its crystallization, which becomes more than half its weight; and is changed by this solution into a white powder, which is very different from the former, and is called *sal catharticus marinus*. It may be obtained in its former crystallized state.

## L I X I V I A L S A L T S.

This is a general name given to all saline substances obtained by lixiviation of ashes, but is particularly applied to fixed alkalis, because the salts thus obtained from ashes are altogether or mostly alkaline. See ALKALI (FIXED).

## N E U T R A L S A L T S.

If this name be taken in its most extensive sense, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic substances. These are salts formed with basis of fixed alkali, vegetable or marine; with basis of volatile alkali, called ammoniacal salts; or with bases of calcareous and argillaceous earths; and, lastly, those with bases of metallic substances. See the above enumeration of *salis*.

The name *neutral*, given to these salts, relates to the reciprocal saturation of their acids and their bases. This saturation ought to be such, that the properties of the two principles of the neutral salt should be neither those of a pure acid, nor of its pure basis, but mixed or intermediate; and from hence these salts have also been called *intermediate salts*, or *sales medii*.

The most important consideration concerning these salts, is the just saturation of their two component principles. A neutral salt ought to be considered as perfect in its kind, when its acid and basis are each of them in the most perfect relative saturation; that is, when the acid and the basis are united together in as large quantity and as intimately as they can be, each according to its nature. But we must remark upon this subject, that a neutral salt may be perfect in its kind, and exactly saturated in the sense we have mentioned, altho' its principles be very far from being completely or absolutely saturated; that is, altho' they have not exhausted upon each other all their tendency to combine. In this respect the neutral salts differ much; and on this chiefly depend the essential differences evidently observable in the taste, solubility, crystallization, deliquescence, facility of decomposition, and action upon other substances, of these neutral salts.

From a circumstantial examination only of the properties of neutral salts, we can acquire any knowledge concerning them; but we are far from having sufficiently examined them: for besides that many saline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning those salts which are best known. We need not therefore be surprised that we cannot yet establish a good general theory concerning neutral salts. We shall here only mention some general principles which seem to result from what is already known, and which seem capable of leading us to further researches.

First, the neutral salts resulting from the union of acids in general with fixed alkalis, are more absolutely saturated than those with basis of volatile alkali, and these more than salts with basis of earth, excepting selenites; and, lastly, the salts with basis of earth are more absolutely saturated than salts with metallic bases. In the first class of these salts, namely, those with basis of fixed

fixed alkali, we find most of the salts which have the least taste, solubility, deliquescence, action upon other bodies, or facility of decomposition, and the greatest tendency to crystallization. On the contrary, in the last class, namely, the salts with metallic bases, we find most of those that are corrosive, most soluble, deliquescent, least crystallizable, most active upon other substances, and most easily to be decomposed. The two intermediate classes with bases of volatile alkali, and of earth, are also intermediate with regard to these properties.

Secondly, as the several acids are more or less simple and powerful, they form with the substances to which they are capable of uniting, neutral salts, the absolute saturation of which is more or less perfect, according to the nature of the acid. Neutral vitriolic salts are the first in this respect, then nitrous and marine salts, or marine and nitrous salts; for these acids do not differ much; and, lastly acetous and tartareous salts.

We ought to observe upon this subject of general considerations upon neutral salts, that we must not judge, from one or a few of their properties, concerning the degree of cohesion and of absolute saturation of their principles, but from all their properties taken and compared together; because possibly one of the principles of a salt may be absolutely, or almost absolutely, saturated, while the other principle may be far from this degree of saturation; and according as the acid or the base is most saturated, the properties of the neutral salt must vary considerably. For example; we should be much mistaken, if, upon considering that corrosive sublimate is less soluble in water than common salt, and not at all deliquescent, as the latter salt is a little, we should conclude, that the cohesion of the principles of corrosive sublimate and their absolute saturation are much stronger than in common salt. The corrosive quality of this salt, and its powerful action upon many bodies, which properties do not, or scarcely, exist in common salt, evidently prove the contrary. *See* SUBLIMATE (CORROSIVE).

We must also observe, that in many combinations of neutral salts, and particularly of those with metallic bases, some metals and the acids themselves suffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic salt resulting from their union: for instance; although lunar and mercurial nitre be crystallizable, and little, if at all, deliquescent, while the nitrates with bases of copper and of iron are very much so, we must not thence conclude, that iron and copper saturate the nitrous acid less than silver and mercury do; because we are certain that this difference does only proceed from this circumstance, that while the nitrous acid dissolves copper and iron, it decomposes them, and deprives them of much of their inflammable principle which is necessary to the connexion of metals with acids, while it does not produce the same effect so evidently upon silver and mercury. Accordingly, the salts, which result from the solution of copper and of iron by nitrous acid, ought not to be rigorously considered as combinations of these metals, but rather as combinations of their earth with this acid; for as nitrous acid quits silver and mercury to dissolve copper and iron, probably if this solution could be made without loss of the phlogiston of these latter metals, they would more completely saturate this acid, and more firmly adhere to it, than the former metals.

Many

Many other considerations of this kind may be made concerning the different kinds of neutral salts; but the detail of them would engage us too long, besides that they will easily occur to those who would attentively reflect on this subject. We will however mention something concerning a discussion that has arisen lately betwixt some chemists relative to neutral salts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that several of these salts may be in two different states; that is, they may be in a state of a perfect saturation; or, they may have an excess of acid. He cites for examples several combinations of metallic matters with acids, such as those of mercury with marine acid and with vitriolic acid, and that of bismuth with nitrous acid. Each of these metals may, according to him, form with the same acid two very different neutral salts, one of which has an excess of acid, and contains the largest possible quantity of acid; and the other is precisely saturated, and contains the smallest quantity possible of acid. This chemist cites also, as another instance of the same doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming consequently the neutral salt called *vitriolated tartar*. Mr. Beaumé has opposed this opinion in many Memoirs read at the Academy, and also in the Journal and Gazette of Medicine. He disputes the facts upon which Mr. Rouelle establishes his theory. He maintains, that many of the saline metallic combinations cited by Mr. Rouelle as examples, and considered by him as neutral salts containing the least possible quantity of acid, are nothing less than salts, but metals, deprived of all acid, when the acid which adheres superficially to the precipitated metal is sufficiently washed from it; and he thinks that Mr. Rouelle has been mistaken, from not having sufficiently washed these metallic precipitates, which he considered as salts. Mr. Beaumé proves his opinion, by washing with a very large quantity of distilled and boiling water turbith mineral and mercurius vici, which precipitates he, by this method, deprived of every particle of acid.

With respect to the vitriolated tartar, the process by which Mr. Rouelle gives it an excess of acid is, by distilling in a retort two ounces of pure vitriolic acid upon this salt, till the salt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle observes, that when vitriolic acid is poured upon this salt, a considerable heat is excited, even when the salt has been deprived of the water of its crystallization by drying; and thence concludes, that the acid acts upon and combines with the salt. The saline mass remaining after the distillation melts, and weighs, as Mr. Rouelle has observed, five ounces and one gros. This, according to him, is vitriolated tartar with excess of acid. He asserts also, that in this salt, as in all those which are susceptible of receiving excess of acid, there is a point of saturation of this excess of acid; and this point is marked in the present operation by the ceasing of white vapors which rise during the distillation. This vitriolated tartar with excess of acid has really an acid taste, attracts the moisture of the air, resolves in a liquor, like the deliquescent salts, reddens the tinctures of violets and of turnsole, effervesces with fixed and volatile alkalis; and, lastly, in crystallizing, resembles with

Mr. Beaumé acknowledges almost all these facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an excess of combined acid. He supports his opinion upon the following facts and reasons:

Vitriolic

Vitriolic acid distilled from pure sand, in the same manner as Mr. Rouelle distilled that acid from vitriolated tartar, adheres to it in the same manner, although we are certain that it does not act upon sand. In this therefore, and in many cases, it is only an adhesion of juxtaposition, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, especially when perfectly concentrated.

In the second place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolated tartar is only superficially covered, by Mr. Rouelle's process, is so far from being truly combined, that it may be entirely separated without fire, or any intermediate substances, by means purely mechanical: for by draining this salt very carefully upon brown paper, or even upon clean sand, a vitriolated tartar perfectly neutral may be obtained, which preserves the water of its crystallization, and consequently the form and solidity of its crystals, and which no longer contains any vestige of an acid. From these experiments Mr. Beaumé concludes, that this excess of acid in vitriolated tartar is not real, and is, like the unwashed metallic precipitates, mistaken for salts with the least possible quantity of acid, one of those deceitful appearances against which we cannot too much guard. Mr. Beaumé generalises his proposition concerning the excess of acid of vitriolated tartar, and affirms, that no neutral salt with basis of fixed alkali either has an excess of combined acid, or of combined alkali, although it be crystallized in an acid or an alkaline liquor; and that the acid or alkali, with which these salts are mixed, when crystallized in such liquors, is only interposed betwixt their parts, and may always be carefully separated from them solely by the mechanical method of imbibition.

We shall not enter more particularly into these subjects, which perhaps will hereafter be further illustrated. We shall only observe, that if we were to examine these matters as well as they deserve, it seems essential to distinguish first metallic salts from all others; for the greater or less degree of concentration of acids seems indifferent, with regard to the saline combinations which result from the union of these acids with earths and alkalis both fixed and volatile; that is to say, the same quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water: but metals, especially some certain metals, cannot be combined, or remain combined with acids, in the greatest possible quantity, unless the acid employed be in a proper degree of concentration; so that the same quantity of the same acid, which, when sufficiently concentrated, is capable of remaining united with a certain quantity of metal, can dissolve only a much less quantity of the same metal, if this quantity of acid be diluted with a larger quantity of water.

This singular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their composition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at least much more by the former than by the latter: But on the other side, the union of water with any body is an obstacle to the combination of that body with the inflammable principle. A quantity of acid therefore, diluted with water, cannot be united but with a less quantity of metal than the same quantity of acid when concentrated. This seems to be naturally deduced from the fundamental principles of chemistry.

In the second place, we may remark, that after having distinguished metallic salts from all others, we ought also to distinguish the combinations of mercury and marine acid, and other the corrosive metals, from all other metallic salts. These salts make a distinct class, and have a peculiar character. See upon this subject the article SUBLIMATE (CORROSIVE).

Notwithstanding the distinctions we have shewn between the different kinds of neutral salts, we are far from believing that they can be methodically distributed, from considering any of their common properties, or classed, as plants have been by botanists, because each of them has so many peculiar, and, at the same time, very essential, properties, that the salts in the same class would often differ more from each other in their peculiar properties than they would be similar in their common property by which the class is characterised. A proof of this truth may be seen in a Memoir inserted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to class neutral salts according to their crystallization: for we find very different salts ranged not only in the same section, but also under the same genus, as, for instance, *sal ammoniac*, and the combination of *hard solid marine acid*. We do not mean to depreciate Mr. Rouelle's attempt upon this subject, or those of others in the same way, as we are convinced, that however unsuccessful there may be in their particular object, they must increase our knowledge by the many experiments and observations which they require, and by the comparisons and new views they occasion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this.

Neutral salts have many uses in chemistry, arts, and medicine; but as these uses depend upon the peculiar nature of each of them, we refer to the particular articles, and here we shall only say a little concerning their medicinal virtues.

We may observe, that these salts are antiseptic when mixed in a proper dose, that is, in a large dose, with substances capable of putrefaction. Each of them resists all kinds of fermentation more or less effectually: but the most exact experiments that have been made on this subject by Sir John Pringle, by the author of the Essay on Putrefaction, and by Mr. Gardane, physician at Paris, prove that these neutral salts, the principles of which are firmly combined, as all those with salts of fixed alkali, particularly ammoniac salt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Essay on Putrefaction, that the most powerful antiseptics among the neutral salts are those which are most stringent, as the neutral salts with acetic taste.

All neutral salts with salts of fixed alkali taken internally in the dose of an ounce at once, produce in several cases a mild purgative effect; and in small doses, as a tonic, in dyspepsia, and in other cases.

Antiseptic salts are given in small doses only. They are exciting, digestive, and antiseptic. The common balsamiac is the only antiseptic.

Neutral salts with salts of volatile acids are also considered as astringent, and are given in small doses according to the nature of their acids. They are given in small doses, and are distinguished from acids and marine acids with fixed alkali. Of these salts only the acetous, such as the salts of tartar, pearl, &c. are employed, and these but very little in France.



All the salts with metallic bases are corrosive, especially those containing mineral acids. Accordingly, they are not internally employed in medicine, excepting some of those with bases of mercury, iron, regulus of antimony. See the articles IRON, MERCURY, REGULUS of ANTIMONY, and TARTAR (EMETIC).

## NEUTRAL ARSENICAL SALT.

This salt is a combination of arsenic with fixed alkali to the point of saturation. Mr. Macquer first discovered this combination, and began an account of its properties in the *Memoirs of the Academy* for the years 1746 and 1748. His method of making this salt is, by mixing together equal parts of very white crystalline arsenic and purified nitre, and by distilling this mixture in a retort with a graduated heat in the usual manner, till the retort is red-hot, and no more vapors of nitrous acid arise. In the retort a saline mass remains, white, compact, and fixed, from which, after solution in hot water, filtration, evaporation, and crystallization, may be obtained beautiful, quadrangular, prismatic crystals, terminated at each end by a quadrangular pyramid, the sides of which correspond with those of the prism.

Arsenic is known to have the property of decomposing nitre, and of very easily disengaging its acid; but, at the same time, it combines with the alkali of the salt, and saturates it precisely as an acid would do, so that the new salt which results from this operation when well made, is exactly neutral, and gives no marks of an alkaline quality. It is infinitely more soluble in water than pure arsenic, and dissolves in a less quantity of hot than of cold water.

This salt is easily fusible by fire, and remains fused and transparent like glass, without being alkalised, if it has not touched any inflammable matter: for it may be easily decomposed by phlogiston which unites with the arsenic, separates it from the alkali, and is sublimed. No pure mineral acid can decompose this salt, because arsenic seems to have a greater affinity with fixed alkali than acids have: but when these acids are united with metallic matters, they then easily decompose the neutral arsenical salt, even by the humid way, so that a solution of this salt added to a solution of metals occasions a precipitate composed of the arsenic and metal, while the acid of the metallic solution combines with the fixed alkali of the neutral arsenical salt, and forms another neutral salt. Thus two decompositions are made, and two new combinations are formed.

The uses of the neutral arsenical salt are not yet well ascertained, yet as the arsenic seems, from the properties mentioned, to be closely united with the fixed alkali, this salt may probably be usefully employed, 1. in the preparation of the regulus of arsenic; 2. in combining arsenic concretions with metallic matters; 3. in the composition of many glasses; 4. as the corrosive mineral acids form very good salts when combined with alkali, and are therefore to be believed that arsenic combined with alkali will form salts, which may be used in neutral arsenical salt, though for a long time it has been thought that it will never be used.



tried: but if it should, very numerous and long trials ought to be previously made on animals.

This salt might probably be useful in arts; for Mr. Beaumé prepares large quantities of it for different manufactures; but the uses to which it is applied are kept secret. See *ASSENIC*.

### SALT of MILK.

Salt of milk is a neutral salt of a singular nature, and very little known. It is obtained from whey by evaporation and crystallization. As the evaporated whey from which it is obtained has a red color, and a saccharine taste, that part of the salt of milk, which crystallizes first, has the same color and taste; and hence it has been called *sugar of milk*. If it be required more white and pure, it must be again dissolved in pure water, and crystallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is less saccharine, and has in general less taste; because it is disengaged from the saccharine part of the milk, and even from a little common salt, which may afterwards be separated from the whey.

Crystals of this salt seem to contain very little water: they have little taste, are not deliquescent, nor very soluble, and seem to be difficultly decomposed. They deserve a farther examination.

Some persons have imagined, that a liquor like whey might be made by dissolving salt of milk in pure water; but this salt is only one of the constituent parts of whey, and consequently the purer it is, the less can its solution imitate that liquor. See *MILK*.

### SAL POLYCHREST.

The word polychrest is applicable to things which have many uses: accordingly chemists say, that a furnace is polychrest when it is so constructed that different operations may be made with it.

For the same reason, the inventors of some salts have given them this epithet to denote their various powers in medicine. Hence we have the *sal polychrest* of *Geber*, which is a vitriolated tartar, made by the decomposition of nitre with sulphur; the *sal polychrest* of *Boerhaave* or of *Saigonette*, which is a tartareous salt, or a soluble tartar with basis of marine alkali. See *SALT of SAIGONETTE*, and *TARTAR (VITRIOLATED)*.

### POTASH.

Potash is a purified, fixed, vegetable alkali, obtained from the ashes of wood. See *ALKALI (VEGETABLE)*.

## SALT of SAIGNETTE or of ROCHELLE.

This salt is a soluble tartar with basis of marine alkali, or a neutral salt formed by saturating the acid of tartar with marine alkali.

This salt was first composed for medicinal purposes, in imitation of ordinary soluble tartar or vegetable salt, by Mr. Saignette, apothecary at Rochelle, who brought it into vogue, and kept it secret as long as he could. Mess. Boulduc and Geoffroy afterwards discovered, and published its composition.

To prepare this salt, crystals of marine alkali are to be dissolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervescence ceases, more cream of tartar is to be added, till the liquor is saturated: it is then to be filtered and evaporated; and very fine and large crystals may be obtained by cold, each of which is the half of a polygonous prism cut in the direction of its axis. This facet, which forms a face much larger than the rest, is, like them, a regular rectangle, distinguishable however from the others, not only by its breadth, but also by two distinct diagonal lines which intersect each other in the middle.

Mr. Beaumé has observed, that the crystallization of this salt, and also of the vegetable salt, is much more easy and beautiful when the liquor in which it is made contains an excess of alkali, which does not prevent the salt from being exactly neutral, after it has been well drained.

Salt of Saignette has a saline taste, moderately strong, and disagreable. It retains much water in its crystallization, is soluble in a less quantity of hot water than of cold water, and consequently crystallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its crystallization, and from the marine alkali which enters its composition. In other respects, it has all the general properties of *neutral tartareous salts*, or *soluble tartars*.

Salt of Saignette is used only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much used as such, and is, for that purpose, dissolved in pure water, or in pills and mineral waters, to render them purgative. It is also given in small doses of one or two gros, as an alterative, aperitive, and corrector of other purgative substances. Altho' this salt really possesses these good qualities, it does not seem to differ much from ordinary soluble tartar, to which it is generally preferred. See TARTAR, ALKALI (MINERAL), and TARTAR (SOLUBLE).

## S A L E S S A L S I

This is one of the names given to neutral salts, particularly to those which have a taste something resembling that of common salt. See SALT (NEUTRAL).

## SEDATIVE SALT.

This salt is a saline, concrete, and crystallized substance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly saturates its alkali, has not an acid taste, nor the property of reddening the tinctures of violets and turnsol, as the acids properly so called do. Sedative salt has little taste and solubility in water. It is a kind of neutral salt, which has only some properties common to it with acids, as we shall afterwards see.

Sedative salt may be obtained from borax by sublimation, or by crystallization. The most common process for obtaining this salt by sublimation is that of Homberg, the discoverer of sedative salt. This process consists in mixing martial vitriol with borax, in dissolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a small glass alembic, and the sublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor passes into the receiver; but the internal surface of the capital is covered with a saline matter forming very small, thin, laminated crystals, very shining and very light. This is the sedative salt. The capital is then to be unluted, and the adhering salt swept off with a feather: the part of the liquor which passed left into the receiver is to be poured on the dry residuum of the cucurbit, and a new sublimation is to be promoted as before, by distilling till the matter in the cucurbit be dry: these operations are to be frequently repeated in the same manner, till no more sedative salt can be sublimed.

Sedative salt may be obtained by crystallization. For this purpose, let borax be dissolved in hot water; and to this solution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be saturated, and even have an excess of acid, according to Mr. Beaumé's process: the liquor is then to be left in a cold place, and a great number of small, shining, laminated crystals will be formed: These must be washed with a little very cold water, and drained upon brown paper. This is the sedative salt obtained by crystallization. It is very beautiful and shining, but is somewhat denser than the salt obtained by sublimation. This latter is so light, that one gros is sufficient to fill a large phial.

The acids, either of the martial vitriol, or the disengaged acids in the latter process, do only disengage this salt from the marine alkali with which it formed borax, as Mr. Baume has discovered. Accordingly, this salt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been disengaged. Sedative salt obtained by crystallization does not differ essentially from that which is sublimed, only that the crystals or laminations of the latter are more separated and detached than those of the former.

Sedative salt, although it be thus sublimed, is not however volatile; for, as Mr. Baume observes, it only rises by means of the water of its crystallization. We know that, when once it has lost its water by drying, it cannot be raised

into vapors by the most violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified sedative salt preserves its saline character; and, although it has a beautiful crystalline appearance, it is only sedative salt deprived of all moisture and melted. It is entirely soluble in water, and may then be crystallized or sublimed, as at first, into its proper form.

A great quantity of water is required to dissolve sedative salt, and much more of cold than of boiling water. It may therefore be crystallized by cold, and is also crystallizable by evaporation alone.

Mr. Beaumé has made an interesting observation upon this method of disengaging and crystallizing sedative salt, which is, that we must add a little more acid to the solution than is sufficient for the saturation. He remarks, that when only the precise quantity of acid is added to decompose all the borax, the sedative salt remains confounded with the other saline matters contained in the liquor and the crystallization is consequently disturbed. This inconvenience is avoided by the addition of a little more acid than is sufficient for the saturation of the alkaline basis of the borax. The sedative salt, although formed in a liquor thus acidulated, may be entirely deprived of any excess of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaumé.

The acid that is mixed in the hot solution of borax decomposes this salt, becomes saturated with its alkaline basis, and instantly disengages the sedative salt; all which is effected without any effervescence. The sedative salt does not crystallize as soon as it is disengaged, although the liquor be at the point of crystallization, when only the precise quantity of water is added which is necessary for the solution of the borax. The heat is the cause of this; for as soon as the liquor cools, a considerable quantity of crystals is perceived.

From the above-mentioned properties of the sedative salt, by which it resists fire, so as to be capable of vitrification, without being otherwise altered, we may perceive that it is a saline compound, the principles of which are strictly united, and very difficultly separable. This truth has been illustrated by numerous and accurate experiments on this subject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From these experiments we find, that sedative salt resists the most powerful agents for the decomposition of saline substances. It was unaltered by treatment with inflammable matters, with sulphur, with mineral acids disengaged, or united with metallic substances, and with spirit of wine. Mr. Bourdelin could only perceive some marks of an inflammable matter, and a little marine acid, in this salt. The former he discovered by a smell of sulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a solution of mercury, by the liquor obtained from the distillation of a mixture of this salt with powder of charcoal. Mr. Bourdelin does not positively affirm the last proposition; but acknowledges, with all chemists, that we do not know the nature of sedative salt, from not having been able to decompose it.

As this salt has the property of disengaging the acids of nitre and of common salt by uniting with their bases, and also as it is very vitrifiable, and promotes

motes the vitrification of other substances, most chemists believe that it is composed of vitriolic acid intimately combined with a fusible and vitrescible earth.

This is one of the salts which are soluble in spirit of wine, to the flame of which it communicates a green color. As only the saline combinations of copper are known to be capable of giving this color to the flame of spirit of wine, some chemists have been induced to believe, that sedative salt might contain copper, or the calx of copper.

Lastly, we may suspect some analogy betwixt the sedative salt, on one side, and arsenic and phosphoric acid on the other, from some properties which each of these substances have, and particularly from their action upon certain salts, and from their vitrescible quality. But these latter substances are not better known than sedative salt; therefore all that we can say upon this subject is, that much yet remains to be discovered concerning all these matters.

Excepting the uses of borax in vitrifications, and in fusions and soldering of metals, sedative salt is only employed in medicine. Homberg, its inventor, believed that he discovered in it a sedative, antispasmodic, and even narcotic quality, and thence called it the *narcotic-salt of vitriol*.

It was generally employed in convulsive diseases after the praises Homberg had bestowed upon it; but its sedative powers have not been well ascertained. The best practitioners even affirm, that, to produce any effect, it must be given from half a gros to a gros, instead of doses of a few grains, which were given at first. See BORAX. (1)

## S A L T of S O D A.

This is one of the names given to marine or mineral alkali obtained from the ashes of soda and of other maritime plants. See ALKALI (MINERAL).

## S U L P H U R E O U S S A L T of S T A H L.

This name is given to a neutral salt, composed of volatile sulphureous acid, combined to the point of saturation with fixed vegetable alkali.

(1) SEDATIVE SALT. Mr. Cadet has published, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of some experiments made by him upon borax and the sedative salt. From these he infers, 1. that the acid contained in borax is the marine, he having made a corrosive sublimate with this acid and the mercurius præcipitatus per se. 2. That the sedative salt does not exist in borax, but is produced during the process. 3. That this sedative salt is composed of the marine acid originally existing in the borax, of the vitriolic acid employed in the operation, and of a vitrescible earth. 4. That this vitrescible earth is the same as that which is generally separated from borax during its solution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth consists of a calx of copper, from which by reduction he obtained a regulus of copper. 6. That borax therefore is composed of a calx of copper united with marine acid, and with mineral alkali. The same chemist purposes to make further experiments on this singular salt.

This

This salt may be made either by saturating fixed alkali with volatile sulphureous acid made in a cracked retort, in Stahl's manner, or by exposing linen soaked in liquid fixed alkali to the vapors of sulphur slowly burning. When this latter method is employed, the linen dries, becomes stiff, and shines with many small, needle-like crystals, which are the sulphureous salt.

Volatile sulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiston, which is only weakly united with it, but is however sufficient to disguise considerably the essential properties of this acid. Sulphureous vitriolic acid has not only a pungent smell and volatility which the pure vitriolic has not, but it also forms with different substances, particularly with fixed alkali, neutral salts very different from those formed by the union of these substances with pure vitriolic acid. Stahl first observed this salt, which is the only one known of all the combinations of the sulphureous acid.

This sulphureous salt has a more pungent taste than vitriolated tartar, is more soluble in water, and is crystallizable by cold. Its crystals are like needles attached to each other by their ends, forming tufted clusters of crystals, in which respect also it differs from vitriolated tartar, and is somewhat analogous to nitre.

This salt may be decomposed by any acid, and its sulphureous acid expelled from it. Thus vitriolic acid, from being naturally the strongest of any, is rendered the weakest of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogistic principle, and its weak adhesion to the volatile sulphureous acid, occasion a gradual change of the nature of the sulphureous salt. This salt is perpetually changing, from the constant dissipation of its phlogiston. It gradually loses its peculiar properties by which it differs from vitriolated tartar, becomes more and more similar to this salt, and at last, when it has lost all its phlogiston, does not in any respect differ from it. Probably we might observe the same changes in the combinations of sulphureous acid with other substances; nevertheless those which, like metals, have a stronger affinity with phlogiston than alkali has, may perhaps produce effects very different.

All the phenomena of the sulphureous salt, of the volatile sulphureous acid, and of sulphur, with regard to their several combinations, are naturally deducible from this general principle, that the affinities of the most compound bodies are always weaker than those of the most simple substances. *See VOLATILE SULPHUREOUS ACID, and ACID (VITRIOLIC).*

## FEBRIFUGAL SALT of SYLVIVS.

This is a neutral salt composed of marine acid saturated with fixed vegetable alkali. It is also called *regenerated sea salt*, but improperly, because the basis is different from that of sea salt. Excepting its taste, which is not so agreeable as that of sea salt, it resembles this salt in its crystallization, and in most of its essential properties. It does not seem to deserve the epithet *febrifugal*, although it may, when given in proper doses as a purgative and antiseptic, contribute

contribute to the cure of some fevers, which qualities are common to it with other neutral salts. It is not now employed. See ACID (MARINE), ALKALI (FIXED), and NEUTRAL SALTS.

### S A L T S of T A K E N I U S.

The salts prepared in Takenius's manner are impure fixed alkalis, obtained from the ashes of vegetables burnt for that purpose in a peculiar manner, namely, by suffocating their flame, and leaving no more communication with the air than is sufficient for the burning of their most disengaged inflammable parts.

When therefore we would prepare the fixed salts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated so that its bottom shall be red. The plant must be continually stirred; a thick fume will exhale from it, and at length a flame rises. The pot is then to be covered with a lid, which must be so loose that the flame only will be extinguished, and the smoke will pass out. The lid must be taken off sometimes, that the plant may be stirred. When the plant is by this method reduced to a kind of ashes, these ashes must be lixiviated with boiling water; and when the lixivium has been evaporated to dryness, a saline matter more or less reddish will remain, which ought to be kept in a bottle. This is the fixed salt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogisticated, rendered semi-saponaceous, similar to that which is prepared for the making of Prussian blue, and mixed with all the neutral salts contained in the plant. These impure alkalis have been intended only for medicinal uses. Some persons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed salts of different plants, prepared in this method, differ considerably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as these principles are totally changed, and decomposed by burning, even when they are made with the precautions which Takenius mentions, these salts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only semi-saponaceous fixed alkalis, much less caustic than well purified alkalis, and which therefore may be preferred in medicine. These alkalis partake besides of the virtues of the neutral salts with which they are mixed.

### S A L T of T A R T A R.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. See ALKALI (FIXED).

### V E G E T A B L E S A L T.

This salt, called also *soluble tartar*, and *tartarised tartar*, is a combination to the point of saturation of cream of tartar, or acid of tartar with fixed vegetable

table alkali. It is prepared and crystallised like salt of Saignette, from which it differs in its alkaline basis. The crystals of this salt are much smaller than those of salt of Saignette. In other respects it has the same properties, chemical and medicinal. See SALT of SAIGNETTE, TARTAR, and TARTAR (SOLUBLE).

### S A L T of V I N E G A R.

The salt sold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very strong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete state but with very great difficulty, and as it does not retain this concrete state when it has once received it, as the Count de Lauraguais has shewn, when a salt of vinegar is required with a very pungent and penetrating smell, to be kept in bottles, like the concrete volatile alkali called salt of England, a better expedient has not been found than that we have mentioned. This mixture has a smell of radical vinegar, almost as pungent as that of volatile alkali, although the kind be very different; and is applicable to the same purposes, namely, to relieve hysterical paroxysms. See VINEGAR.

### V O L A T I L E S A L T S.

This name is frequently given to volatile concrete alkaline salts. Thus *volatile sal ammoniac*, and *volatile salt of hartshorn*, are the volatile alkalis obtained from these substances. Nevertheless, the same name is sometimes given to other saline substances of very different natures, for instance, *the salt of amber*, which is acid, and is called *volatile salt of amber*, which is certainly an inconvenience. The appellation *volatile salt* may be given to all saline matters really volatile, that is, which may be sublimed with a moderate heat. But as these salts are of very different kinds, they ought to be distinguished by some more particular name. The volatility of salts is a very indeterminate quality. For of those which are considered as such, some are much more, and some much less volatile than others.

These salts are called *semi-volatile* which cannot be sublimed without a fire sufficient to render the bottom of the vessel containing them red-hot, such as frost ammoniacal salts, sweet mercury, and some others. And those are called *fixed salts* which may be kept red-hot during a certain time without sensible loss. But, rigorously speaking, no salts are absolutely fixed; for, as we have said elsewhere, the alkalis called fixed, and the other salts which are considered also as fixed, are dissipated in fume when long exposed to violent fire, with access of air. See ALKALIS (VOLATILE), FIXITY, VOLATILITY.

### U R I N O U S S A L T S.

This name was given by ancient chemists to all alkaline salts, volatile or fixed; to the former, because they all have the taste of putrescent or distilled urine;



urine; and to the fixed, because although they have not themselves this taste, they however occasion it, when applied to the tongue, by disengaging the volatile alkali contained in animal substances. Therefore *urinous salts* and *alkaline salts* are synonymous. See ALKALI.

## S A L T of S T E E L.

Some chemists have given this name to several combinations of iron with acids, even to martial vitriol, as appears from *Riverius's salt of steel*, which is a martial vitriol made with iron, vitriolic acid, and spirit of wine. See VITRIOL.

DCIX. S A L T - P E T R E. See NITRE.

DCX. S A N D. Sand is composed of small stoney matters. The kinds of sand may therefore be as many as the kinds of stones. Most sands consist of different kinds of stones mixed together. But as soft stones are easily reducible into so small particles, that they are more like powders or earths than sand; and as the molecules of hard or vitrifiable stones are capable of preserving longer their size; hence most matters called sand are of the nature of vitrifiable earths. See EARTHS (VITRIFIABLE). Accordingly, by the name of sand, we understand always, in natural history and in chemistry, a matter of the nature of vitrifiable earths.

The principal use of sand in chemistry is in compositions for pottery and glass. Some sands are more and some less fusible. The particles also of some are larger than those of others. The finer kind is generally used for vitrifications, and other chemical operations, because it is naturally much divided: It is frequently employed to make a *sand-bath* to transmit heat to vessels placed in it.

DCXI. S A N D A R A C H. This is a yellow or red combination of arsenic with sulphur. See ARSENIC, and REALGAR.

DCXII. S A N D I V E R. See GLASS-GALL.

DCXIII. S A P H I R E. (u)

DCXIV. S A R C O C O L L A. (x)

DCXV. S A R S A P A R I L L A. (y)

DCXVI. S A S S A F R A S. (z)

(u) SAPHIRE is the name of a pellucid blue gem, the hardness of which is next to that of the ruby. By fire it is unfusible, but its color is thereby destructible. It may be imitated by fusing a hundred parts of crystal-glass-frit with one part of zaffre, and a very small proportion of manganese.

(x) SARCOCOLLA is a gum-resin, of an ounce of which six drams were found to be soluble by spirit of wine; and seven drams and a half were found to be soluble by water. *Neuman.*

(y) SASSAPARILLA. From sixteen drams of this root *Neuman* obtained by water

six drams of gummy extract, and from an equal quantity he obtained by spirit four drams of resinous extract.

(z) SASSAFRAS. The wood of this tree contains the heaviest of all known essential oils. Of this oil *Hoffman* obtained an ounce and six drams from six pounds of the wood; and *Neuman* obtained from an equal quantity of wood, two ounces. From an ounce of *sassafras* four scruples of extract were obtained by means of rectified spirit; and from an equal quantity of the wood, two drams were extracted by water. *Neuman.*

DCXVII. **S A T U R A T I O N.** All the particles of matter have, as is said under the articles **AFFINITY**, **COMBINATION**, **SOLUTION**, and **GRAVITY**, a tendency to unite one with another. In fact, when they are united, and when this tendency is satisfied, it is called the state of *saturation*, and then the whole effect of this tendency, or of this force, consists in making them cohere together. But all the phenomena of chemistry show, that the tendency to union of the parts of different substances is more or less strong, according to the nature of these substances. Hence the parts of two substances may be united together with all the force of which they are susceptible, respectively to each other, although their tendency to union in general be very far from being entirely exhausted and satisfied.

This remark leads us to consider saturation in two views, that is, that we should distinguish the saturation of one substance relatively to another, from the greater or less diminution of tendency to union in general, which a substance has sustained by means of any particular union contracted. This latter we shall call *absolute saturation*, and the former *relative saturation*.

These things being premised, as the general tendency to union diminishes always in proportion to the force with which the parts are united, hence the adhesion, more or less strong, contracted betwixt the principles of any compound, influences much the nature and essential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative saturation is then confounded with their absolute saturation, so that after their union, no tendency to new unions can be perceived in these bodies, or in any of their principles. Such are the neutral salts composed of mineral acids and fixed alkali. So strong an union is contracted by the acid and alkaline principles of these salts, that they lose entirely, or almost entirely, their taste, causticity, activity; in a word, all the properties which before this union were occasioned by their general tendency to combination. Accordingly, the relative saturation of these is very distinct, and is one of the first which has been observed.

When, on the contrary, the principles of a compound can contract together only a weak union, and consequently do not exhaust by this union all their general tendency to combination, not only their point of relative saturation is less distinct, but also these principles, although relatively saturated by each other, are far from absolute saturation, and still preserve, notwithstanding this union, much of their dissolving power. Compounds of this kind are always considerably active, and even caustic according to the nature of their principles. Such are deliquescent salts, and particularly most salts composed of mineral acids and metallic substances, the causticity of which cannot be otherwise explained. See the articles **CAUSTICITY**, and **SUBLIMATES** (**CORROSIVE**).

Many substances have a determinate and considerably distinct point of relative saturation, altho' they contract together but a weak union. But if we attend, we shall perceive that all these substances possess but a small quantity of dissolving power, or a weak general tendency to combination. Their relative saturation is nearly equal to their absolute saturation. Such are ether with water, essential oils with spirit of wine, and most neutral salts with water. If we mix together and agitate good ether with water, a part of the ether unites with

with the water, nearly in the proportion of one to ten; so that if one part of ether be added to ten parts of water, all the ether disappears by being diffused through the water, as the Count de Lauraguais observes. If the quantity of ether be more than one tenth part of the water, the overplus will float distinct upon the surface of the water, like an oil.

Also well rectified spirit of wine can only dissolve a determinate quantity of each kind of essential oil, which quantity varies according to the kind of oil, and to the state in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a resinous state, and the smaller quantity of them is soluble. And also the more highly rectified a spirit of wine is, the larger quantity of oil it dissolves.

Water is the proper solvent of neutral salts. It is capable of dissolving any of them; but most of them only in a certain quantity: and this point of saturation of water differs with different salts, and degrees of heat applied. The point of saturation is most distinct with those salts which contain a small quantity only of the water of crystallization, and which are nearly equally soluble in hot and in cold water. Such are vitriolated tartar, and, still more, common salt.

When the water is once saturated with these kinds of salts, the strongest and longest boiling does not dissolve a grain more, and the overplus of the salt remains entire at the bottom of the boiling water: But boiling water dissolves an equal, or even an unlimited quantity of some salts, chiefly of those which contain much water in their crystallization, such as Glauber's salt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of crystallization of these salts is alone sufficient to keep them dissolved, by means of heat. Hence, when they are exposed to fire without water, they suffer a liquefaction, which is very different from fusion, and is nothing else than a solution of the salt in the water of its crystallization, and consequently lasts only till this water be evaporated. The point of saturation of water for these salts seems to be indeterminate.

Many substances are capable of uniting without being precisely saturated, such as water with any of the following substances; fluor acids, fixed vegetable alkali, fluor volatile alkali, most of the very deliquescent neutral salts, and spirit of wine. Such also are almost all metals uniting with each other: Although many of these substances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhausted in these kinds of union. On the contrary, their union is little else than a very accurate and intimate mixture. Their dissolving power is not satisfied by such an union, but is almost entirely preserved. We need not therefore be surprised, that no precise or determinate point of saturation is observed betwixt these substances. We may say, in general, that the point of relative saturation is so much more exact, distinct, and determinate, as the bodies which unite together have a stronger affinity, as they more completely exhaust upon each other their dissolving power, or as their relative saturation is more nearly equal to their absolute saturation.

The examination of the several degrees of saturation which substances may sustain by combining together, is an object as important as it is new in chemistry. This matter has been scarcely begun, and yet it well deserves the attention of chemists, as it would greatly advance the science. We could not

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treat this subject more fully without repeating what has been said elsewhere. We therefore refer to the articles *affinity, combination, composition, solution, causivity, gravity, salts, neutral salts, corrosive sublimate*; and several others.

DCXVIII. S A U N D E R S. (a)

DCXIX. S C A M M O N Y. (b)†

DCXX. S C O R D I U M. (c)

DCXXI. S E A - W A T E R. See WATER.

DCXXII. S E L E N I T E S. Modern chemists give this name to a sort of neutral salt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of saturation in the most intimate manner. Probably a very considerable quantity of earth enters into this combination, at least if we judge of it by the saturation of vitriolic acid, which appears to be more compleat than in any of the other neutral salts formed with this acid. This truth is sufficiently established by the properties of selenites.

Nature furnishes us with a very large quantity of selenitic matters. Chemists agree that all gypsums or plaster stones, alabasters, and gypseous spars, are nothing else than selenites; but these substances are in large quantities within and upon the earth. We may also artificially compose selenites, by combining vitriolic acid to the point of saturation with calcareous earth. To effect this saturation easily, the calcareous earth must be in fine powder, the acid must be diluted in a very large quantity of water, and more earth must be added than is necessary for the saturation. Selenites may also be conveniently made by

(a) S A U N D E R S. The wood of the tree, *Saundersia*, contains a red coloring material used in dyeing. Its color resides wholly in a resinous matter, and hence is extractable by spirit of wine, and not by water. The red color of Saunders, imparted to spirit of wine, becomes, by diluting the tincture with more spirit, yellow. The resin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniseeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow saunders*, is from its fragrance sometimes employed as a perfume. From sixteen ounces of the rasped wood, digested some days in salt water, two drams essential oil were obtained by cohobation.

Two drams of gummy extract may be obtained from two ounces of the wood, by water; and from an equal quantity of wood, two drams and a half of resinous extract may be obtained by rectified spirit. *Neuman.*

(b) S C A M M O N Y is a gummy-resinous juice, which exudes from the root of a species of convolvulus, in which incisions are pur-

posely made at a certain season of the year. An ounce of Smyrna scammony yielded with water half an ounce of gummy extract, and the residuum yielded with spirit two drams of resin, leaving two drams of impurities undissolved. By applying rectified spirit at first to an ounce of the same scammony, two drams and two scruples of resinous extract were obtained; and from the residuum, water extracted half an ounce of gum, the indissoluble part amounting here to four scruples only. *Neuman.*

(c) S C O R D I U M. An ounce of the dried leaves of scordium yielded with water four drams and a half of gummy extract, and afterwards with rectified spirit fifteen grains of resin. Another ounce, treated first with spirit, gave three drams of resinous extract, and afterwards with water, five scruples and a half of gum. A tincture, made in highly rectified spirit of wine, contains more of the active and less of the mucilaginous parts of this plant, than one made with a weaker spirit.

saturating lime-water gradually with weak vitriolic acid, or, lastly, by pouring this acid into a solution of nitrous or marine salts with calcareous bases. In these latter operations the selenitic salt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well washed from all excess of acid or other extraneous matter, has a slightly nauseous taste, which is scarcely perceptible but by drinking a glass of water impregnated with it, like that of the wells in and near Paris, the sweetish and slightly nauseous taste of which is well known.

This earthy salt is one of the least soluble by water of all the known neutral salts. Seven or eight hundred parts of water are required to dissolve one part of selenites, excepting when its principles are combined, and the salt formed in the water, as Mr. Beaume has observed; for then the water may dissolve four or five times as much. By a slow evaporation it crystallizes, and forms thin laminae, and retains in its crystallization a very small quantity of water.

When it is exposed to a moderate fire, it easily loses this water of its crystallization with its transparency and cohesion of its parts, and is reduced to a white powder.

With a very great fire, it is not fusible when alone, (*d*) but is more easily fusible than pure calcareous earth, by the addition of fluxes, as sand, and clay, and vitrifying salts. It resists the greatest heat without losing its acid. It cannot be decomposed but by phlogiston, by alkalis fixed or volatile; and by metallic solutions in nitrous acid, by means of a double affinity. Thus the solution of mercury readily shews whether a water be selenitic or not, by forming a precipitate of turbid mineral when added to such waters. As selenitic matters are copiously diffused, and almost every where within the earth, most waters of wells, or rivers, contain a greater or less quantity of selenites dissolved in them, as we may easily find by the abovementioned method of trial.

Nothing better shews the extreme difference betwixt vitriolic and other mineral acids, than the comparison of the saline properties of selenites with those of nitrous and marine salts with calcareous bases. The earthy basis is the same in these three salts; but the two latter have a violent, almost caustic taste, and are surprisingly deliquescent; while the first salt is very difficultly soluble in water, and almost insipid. The cause of these differences is, that vitriolic acid is more simple than the other acids, and is therefore capable of being more intimately combined and saturated with calcareous earth.

This kind of salt has been called selenites probably because naturalists found its saline properties so weak, that they thought it ought to be distinguished from other neutral salts by a peculiar name. Perhaps they did not even believe it to be saline; for the nature of selenitic matters has been discovered but lately by experiments of modern chemists.

We are not yet enough acquainted with calcareous earths to know if selenites be of different kinds, or if all the substances to which this name is given are only one and the same salt under different forms of crystallization. If the kinds of calcareous earth be essentially different, they must form with vitriolic

(*d*) From Mr. D'Arcet's Memoir upon the effects of a violent and long continued heat, we find that all gypseous stones, and also the artificial selenitic salts, are fusible and vitrescible by violent fire.

acid.

acid several kinds of selenites also essentially different from each other. But if only one kind of calcareous earth exists, then it can only form one kind of selenites.

We may observe, that amongst the various bodies called by chemists selenites, that is, compounds of vitriolic acid with calcareous earths, some differ much from others, at least externally. These substances are all the gypsums, alabasters, and spars, which some chemists, particularly Mr. Pott, have called gypseous, and, lastly, some crystallizations and stalactites, which have the same principles and the same essential properties as other selenitic substances. See ACID (VITRIOLIC), ALABASTER, GYPSUM, SPAR, and EARTH (CALCAREOUS).

DCXXIII. S E M I - M E T A L. Substances possessing all the metallic properties, excepting fixity and ductility, are called *semi-metals*. Thus every matter possessed of metallic density, opacity, and lustre, which is incapable of uniting with earths, but which is also brittle and frangible by the stroke of a hammer, and capable of being sublimed or reduced into vapors by fire, is a semi-metal. Hitherto we know but five semi-metals, which are *regulus of antimony, zinc, bismuth, regulus of cobalt, and regulus of arsenic*.

Some chemists have numbered mercury amongst the semi-metals, under pretence that it possessed all the metallic properties excepting fixity and ductility: but all semi-metals are combustible, and mercury is no more so than the perfect metals; and also, the want of ductility is falsely imputed to it, since the Academicians of Petersbourg, who some years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary state, the cause of this appears to be, that it is really in fusion: but the most ductile metals lose their ductility by fusion, as this quality necessarily implies solidity. On the other side, the great volatility of mercury does not allow us to class it among metals. This metallic substance is therefore single in its kind, and is really neither a metal nor a semi-metal. See MERCURY.

Mr. Cronstedt has given, in the Memoirs of the Swedish Academy for the year 1751, a description of a new semi-metal: but this metallic substance is hitherto but little known. (e)

DCXXIV. S E N A. (f)

(e) Concerning this new semi-metal discovered by Mr. Cronstedt, see the article NICKEL. See also the note (y) to the article METALS, concerning another new semi-metal which Mr. Justi says that he has discovered in the yellow mica.

(f) SENA. An ounce of the leaves of Sena, treated with fresh parcels of rectified spirit of wine, yielded two drams and twenty-three grains of resinous extract; and afterwards with water, two drams and two scruples of gummy extract, three drams and three grains remaining undissolved. Another

ounce, treated first with water, gave four drams and half a scruple of gummy, and afterwards with spirit only, twenty-eight grains of a resinous extract, which appeared to contain some gross oily matter; and hence was difficultly reduced to dryness. The residuum weighed three drams and a scruple. Water distilled from Sena possesses the peculiar smell of these leaves, but no essential oil appears. The activity of Sena is greatly weakened by evaporation, especially if the process be performed in an open vessel with a boiling heat. Neuman.

DCXXV. S E N E G A L (G U M) (g)

DCXXVI. S E R P E N T I N E - S T O N E. (b)

DCXXVII. S I L K. (i)

DCXXVIII. S I L V E R. Silver, called also *luna* by chemists, is a perfect metal, of a shining white color.

Its specific gravity is, although considerable, nearly one half less than that of gold. It loses in water an eleventh part of its weight. A cubic foot of silver weighs 720 pounds.

The tenacity of its parts is also nearly one half less than that of gold; a silver wire, the diameter of which is  $\frac{1}{16}$  part of an inch, can support only a weight of 270 pounds without breaking.

This metal is, next to gold, the most ductile of all. Very fine wire and leaf may be formed of it.

It is somewhat sonorous and harder than gold, as Juncker observes; and is fusible with a less degree of heat than gold is, according to Cramer. It seems to be as fixed and indestructible as gold is. Kunckel kept silver and gold in a glass-house-furnace during a month without alteration, or more loss than of a few grains, which probably proceeded from a small quantity of extraneous matter, with which it was mixed.

Juncker nevertheless affirms, that silver may be changed into a vitrescent calx, when treated by a long reverberation in the manner of Isaacus Hollandus. This reverberation, consists in exposing metals, reduced into very fine parts, to the action of the strongest heat they can sustain without fusion, with the contact of free air. This method is very effectual for burning the inflammable principle of metals and of all other bodies. But Juncker does not mention the author of this experiment.

The combined action of air and water does not alter the color and brilliancy of silver, nor occasion any rust. Nevertheless, the surface of this metal is apt to tarnish, and even to become black, by the contact of the phlogiston of several inflammable matters, or of their exhalations; because it has the property of impregnating itself with the inflammable principle superabundantly, even in the cold, like some other metallic matters: but silver seems to be more susceptible of this effect than any other metal.

All acids are, with more or less facility, capable of dissolving silver.

Vitriolic and marine acids may be combined with silver in its metallic state; but difficultly, and by particular management.

To dissolve silver directly, vitriolic acid must be much concentrated and very hot; and therefore distillation is necessary, as in the operation of turbith mineral. See TURBITH MINERAL.

(g) SENEGAL (GUM) is a gum, almost pure, and entirely similar in properties to the other pure gums, as gum arabic, cherry-tree and plumb-tree gums. See GUM.

(b) SERPENTINE STONE is a steatites variously colored, but in which the green color generally predominates. See STEATITES.

(i) SILK is an animal substance, from 16 oz. of which may be obtained, by distil-

lation, nine ounces of mixed matters, containing four ounces and two drams of urinous spirit, three ounces six drams of volatile salt, and one ounce of empyreumatic oil. The caput mortuum weighed seven ounces, and lost an ounce on being calcined to whiteness. By elixating the calx, forty grains of fixed saline matter were also obtained. Neuman.

The marine acid cannot attack silver directly; but when it is very much dephlegmated, and, as it were, in a dry state, considerably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. See PARTING (CONCENTRATED).

But silver may be combined with the above-mentioned acids, by methods much more simple and convenient, which we shall describe, after having spoken of the solution of silver by nitrous acid.

Nitrous acid, very pure and moderately strong, dissolves silver in its metallic state with the greatest facility. This solution is made spontaneously without heat, or with a very gentle heat at first; and when the silver has begun to dissolve, the heat ought to be discontinued, to prevent the solution from being too violent, especially if the quantities operated upon be considerable.

By this method nitrous acid may be saturated with silver; and if it be strong, it will dissolve a considerable quantity of that metal.

If the silver thus dissolved be alloyed with copper, the solution will be green, and will preserve this color. If it contain no copper, the solution is at first greenish, which color gradually dissipates, and at last the liquor becomes quite white.

The surface of the silver begins to become black as soon as the acid makes impression upon it. This blackness proceeds from a part of the phlogiston of the nitrous acid, which is applied superabundantly to the surface of the silver.

Black flocks are frequently seen floating in this solution, which are insoluble by nitrous acid, and precipitate to the bottom. These flocks may be a small quantity of gold from which silver is seldom entirely free, or of some other phlogisticated substance, insoluble in nitrous acid.

The solution of silver by nitrous acid is more acrid and corrosive than pure nitrous acid; which property is very remarkable, and is common to it with several other combinations of metals. See an explanation of this property under the article CAUSTICITY.

This solution of silver corrodes all vegetable and animal matters, and stains the skin of a black color, which cannot be effaced till the blackened part be abraded. This blackness can be only attributed to the phlogiston of corroded matters, which unites superabundantly with the silver of the solution employed.

If a solution of silver by nitrous acid be sufficiently evaporated, and left to cool, a large quantity of white crystals will be formed in it, like scales, which are commonly called *crystals of silver*. These crystals are a nitrous salt, the basis of which is silver; for which reason it may also be called *nitre with basis of silver*, or *lunar nitre*.

This salt is fusible with a small heat, and easily loses the water of its crystallization. It becomes black, congeals by cold, and is capable of being moulded.

It is then the famous cautery used by surgeons, and known by the name of *lunar caustic*. See the words PARTING, CRYSTALS OF SILVER, and LAPIS INCAUSTICUS.

Lunar nitre deflagrates upon coals almost as well as the nitre with basis of fixed alkali, which shews a strong adhesion of nitrous acid with silver. Nevertheless, this salt exposed to strong fire in distilling vessels, or in a crucible, may be easily decomposed. The acid quits the silver, and appears in its former state.

Although



Although silver, as we have seen, is more easily soluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of separating it from the nitrous acid, after this has dissolved it.

If vitriolic acid be poured into a solution of silver in nitrous acid, and if it be not diluted in too great a quantity of water, we see immediately the liquors become turbid, and a white precipitate appears, which is nothing else than a new combination made of the silver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new salt with metallic basis. This salt which may properly be called *vitriol of silver*, or *lunar vitriol*, is crystallizable, and actually does crystallize in the very instant of precipitation; but the crystals are so small, from the rapidity of the crystallization, that they have only the appearance of a white powder. They cannot be discovered to be crystals but by means of a good magnifying glass.

The same event happens, if, instead of vitriolic acid, a solution of any salt containing that acid be added to a solution of silver in nitrous acid. The nitre of silver will be thereby decomposed, and a vitriol of silver obtained similar to the former.

Although vitriolic acid engaged in any basis, such as fixed alkali, with which it has a stronger affinity than with silver, does nevertheless quit its basis to combine with this metal, yet we may observe, that in these precipitations two decompositions and two new combinations are always effected, by means of a double affinity. We may therefore see the explanation of this case at the word AFFINITY.

Marine acid, whether engaged in any basis, or disengaged, produces in the solution of silver by nitrous acid the same effect as the vitriolic acid. It separates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine salt with basis of silver*, known to chemists by the name of *Luna cornea*, or *corneous silver*. See LUNA CORNEA. It is called corneous, because this silver, united with marine acid by exposure to fire, may be melted; and may be coagulated by cold into a semi-transparent, semi-flexible mass, like horn.

Luna cornea, although in a saline state, is very little soluble by water. The precipitate which it forms is very apparent: it is composed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be distinguished from vitriol of silver.

These properties of a solution of silver, together with the facility with which it is rendered turbid by the presence of the smallest quantity of vitriolic and marine acids, disengaged or combined with any basis, render it very convenient and much used for the examination of waters, and in other chemical operations, to ascertain the presence of these two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be separated from any acid by absorbent earths, or by fixed and volatile alkalis; and when afterwards fused, it recovers its original properties. Silver, thus dissolved, precipitated, and melted, is generally very pure. We may be certain that silver, which has been formed

into Luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, ~~copper~~, iron, or other metallic substance soluble in aqua regia, and consequently not separable from nitrous acid by means of marine acid.

From what has been said concerning these several decompositions of a solution of silver made by nitrous acid, we may infer that this combination may be decomposed ;

1. By the action of fire alone, which expels the nitrous acid.
2. By phlogiston, which burns and destroys nitrous acid in the detonation of lunar nitre.
3. By precipitation with saline or earthy alkalis, which seize the nitrous acid, and leave the silver disengaged in the state of a precipitate.
4. By vitriolic acid, which seizes the silver, and leaves the nitrous acid disengaged.
5. By marine acid, which has the same effect.
6. Lastly, several metals, and especially copper, having a stronger affinity than silver with nitrous acid, decompose also this solution of silver, by seizing the acid, and obliging the silver to separate from it, which it does by precipitating it in its proper metallic state. See the words PRECIPITATE and PRECIPITATION.

Sulphur dissolves silver by fusion, and forms with it a blackish mass, which may be cut, and which has almost the color and consistence of lead. It is called *fulphurated silver*. This compound is a kind of artificial ore of silver. Some expert persons are said to be able to imitate very well by this mixture some natural ores of silver.

To make this combination, silver and sulphur are laid alternately upon each other in several strata in a crucible, which is to be heated by degrees till the whole be fused. Less heat is required for this fusion than if the silver was alone, because sulphur facilitates the fusion of this, as well as of all other metals difficultly fusible, upon which it is capable of acting.

The sulphur may be separated from the silver by the mere action of the fire, continued during a certain time with access of air. When sulphurated silver is detonated with nitre, this separation is very well and instantly made. As this metal is indestructible by all these agents, it is found to be unchanged by these operations.

Juncker relates, after Kunckel, that if sulphur be dissipated from sulphurated silver by the action of fire ; and if a volatile alkaline spirit of urine be poured upon this silver, a blue color is produced. He adds also, that this does not happen a second time to the same silver, unless it be first cupelled with lead. This chemist concludes from thence, that this color proceeds from copper which the silver receives from the lead. See *Conspectus Chymiae*, Tom. I. p. 893.

Silver is found within the earth in different states. A very small quantity of it is in its natural and malleable state, allayed with copper and gold ; and is then called *virgin* or *native silver* : but silver is generally found in a mineral state, that is, united and incorporated with heterogeneous matters, such as other metallic substances, and the mineralising substances, namely, sulphur and arsenic. It is separated from all these matters by particular processes practised both in essays and in smelting the ore in large quantities. See ORES of SILVER.

Silver

Silver is purified from the alloy of other destructible metals by treating it with nitre, or with lead. The latter method is generally used by refiners, and is called *cupellation*, or *refining*. See REFINING.

All these operations are founded in general upon the destructibility of imperfect metals, and on the indestructibility of silver, which is a perfect metal: but as gold is an indestructible metal, all the purifications of silver, which are only effected by the destruction of metals alloyed with it, are insufficient to separate it from gold. We must therefore have recourse to other operations for the separation of these two metals from each other. These operations, which are called by the general name of *parting*, are founded upon the property which silver has of being soluble by many menstrua which do not act upon gold. These menstrua are;

1. Nitrous acid, which dissolves silver without touching gold. By means of this acid, silver is generally parted from gold, and the operation is called *parting*, without any epithet to distinguish it from the others. See PARTING.

2. Marine acid, which being applied conveniently to a mixture of gold and silver, seizes this latter metal exclusively of the former. As this parting is performed by cementation, and as the marine acid must be highly concentrated, it is called concentrated parting. See PARTING (CONCENTRATED).

3. Lastly, sulphur, which unites also to silver without touching gold, furnishes a third method of separating these two metals. This is called *dry parting*, because it is made by fusion, which chemists call the *dry way*. See PARTING (DRY).

Silver is capable of being alloyed with all metals, and forms with them different compounds, the properties of which may be seen under the word ALLAY.

According to Mr. Geoffroy's table of affinities, those of silver are first to lead, and then to copper, and Mr. Gellert's table mentions only gold.

DCXXIX. S · M · I · L · O · R. This is a name given to an alloy of red copper and zinc, made in the best proportions to imitate the color of gold. See COPPER, BRASS, and ZINC.

DCXXX. S · M · A · L · T. Is a blue glass composed of the calx of cobalt, vitrified and melted with some fritt of glass or crystal. Ground smalt is called *azure*, or *enamel blue*. See AZURE, COBALT, and ZAFFRE.

DCXXXI. S M E L T I N G of O R E S. We have shewn, under the articles *ores* and *pyrites*, the nature of the principal metallic minerals, and the substances of which they are composed. We have also explained, under the article *assay of ores*, the processes by which an exact analysis of these compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to compleat what relates to this important subject, we shall describe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purposes, metals, sulphur, vitriols, and other useful substances contained in metallic minerals: What we shall say upon this subject will chiefly be extracted from a *Treatise on the Smelting of Ores*, by *Schlutter*, translated from the German into French by *M. Niclos*; because this, of all the modern works upon that subject, appears to be the most exact. We shall first describe the operations upon pyritous matters for the extraction of sulphur, vitriols, and alum; and afterwards the operations by which metallic

metall'ic substances are extracted from ores properly so called; from which also are occasionally obtained the same matters as from the pyrites. As the present article is only the sequel of the articles *ores*, *pyrites*, and *essays of ores*, it is evident that these articles ought to be read previously to this.

## EXTRACTION of SULPHUR from PYRITES and other MINERALS.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distill in vessels, which must be close, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Aiten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made several openings. These are called *furnaces for extracting sulphur*. See PLATE II. Fig 9.

In these furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the size of small nuts. Each of these tubes contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a star, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place. From this residuum, which is called *burnings of sulphur*, vitriol is extracted; as we shall presently relate.

The eleven tubes into which were put, at three several distillations, in all nine quintals, or 400 pounds of pyrites, yield from 100 to 150 pounds of crude sulphur, which is so impure as to require to be purified by a second distillation.

This purification of crude sulphur is also done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg. See PLATE II. Fig. 10.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated as soon as the sulphur begins to distill. At three o'clock in the morning, the wooden pegs, which stop the lower holes of the fore-

fore-runners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it also would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech tree, which have been previously dipt in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called *roll-brimstone*.

As sulphur is not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it must be separated previously to their fusion: but as sulphur is of little value, the trouble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expell it. This operation is called *torrefaction*, or *roasting of ores*.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of *Ramelsberg*, in the country of *Hartz*.

This ore, which is of lead, containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher; so that the whole mass shall be a quadrangular pyramid truncated above, whose base is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the center of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladle-fuls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for that purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur to be purified in the manner above related. See PLATE II. Fig. 11. and 12.

As this ore of *Ramelsberg* is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain has

has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur is burnt and consumed, from ten to twenty quintals of crude sulphur are by this method collected.

The sulphur of this ore, like that of most others, was formerly neglected, till, in the year 1570, a person employed in the mines, called Christopher Sander, discovered the method of collecting it, nearly as it is done at present.

Metallic minerals are not the only substances from which sulphur is extracted. This matter is diffused in the earth in such quantities, that the metals cannot absorb it all. Some sulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin sulphur*, the transparent kind called *sulphur of Quito*, and the native flowers of sulphur, as those of the waters of Aix-la-Chapelle. It is also found mixed with different earths. Here we may observe, that all those kinds of sulphur which are not mineralised by metallic substances, are found near volcanos, or hot mineral waters, and consequently in places where nature seems to have formed great subterranean laboratories, in which sulphureous minerals may be analysed and decomposed, and the sulphur separated, in the manner in which it is done in small in our works and laboratories. However that be, certainly one of the best and most famous sulphur-mines in the world is that called *Solfatara*. The Abbé Nollet has published, in the Memoirs of the Academy, some interesting observations upon this subject, which we shall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of sulphur and alum called at present *Solfatara*. It is a small oval plain, the greatest diameter of which is about 400 yards, raised about 300 yards above the level of the sea. It is surrounded by high hills and great rocks, which fall to pieces, and whose fragments form very steep banks. Almost all the ground is bare and white, like marble, and is every where sensibly warmer than the atmosphere in the greatest heat of summer; so that the feet of persons walking there are burnt through their shoes. It is impossible not to observe the sulphur there; for every where may be perceived by the smell a sulphureous vapor, which rises to a considerable height, and gives reason to believe that there is a subterraneous fire below, from which that vapor proceeds.

Near the middle of this field there is a kind of basin three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapors which rise from the bottom of the lake, which being set in motion by the action of subterraneous fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapors are exhaled. Persons who have the itch, come to these pits, and receive the vapors in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapors exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather

weather, the vapors may be evidently seen to rise 25 or 30 feet from the surface of the earth.

These vapors, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, or hangar, supported by a wall behind, and open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow color: but the workmen say they have lost their *stringib*, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground.

These last mentioned stones are broken into lumps, and put into pots of earthen ware, containing each about twenty pints, Paris measure. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the center of each pot is in the center of the thickness of the wall, and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls which form the two sides of the furnace. Betwixt these walls there is a space of fifteen or eighteen inches; which space is covered by a vault resting on the two walls. The whole forms a furnace seven feet long, two feet and a half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base of fifteen or eighteen lines diameter. Lastly, to each of these last mentioned pots there is a wooden tub placed below, in a bench made for that purpose.

Four or five of these furnaces are built under one hangar or shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuums may be more easily taken out.

The fire being kindled in the furnace, heats the first pots containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pot, whence it passes through the pipe of communication into the external vessel. There the vapors are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel is that of a truncated cone, whose narrower end is placed below, and because the hoops of the tub are so fastened that they may be occasionally removed. The mass of sulphur is then carried to the buildings mentioned before, where it is melted for its purification, and cast into rolls, such as we receive it.

## EXTRACTION of VITRIOL from PYRITES.

Sulphur is not the only substance procured from pyrites; for besides that, different kinds of vitriols and alum, according to the nature of the pyrites, are also extracted: so that pyrites may be considered as the ores of vitriols and alum as well as of sulphur.

These salts do not exist in the pyrites ready formed, as the sulphur does; but are, on the contrary, the products of the decomposition of pyrites, and are new combinations resulting from this decomposition. In the pale-yellow martial pyrites, this decomposition is effected without any other means than by exposure to moisture and air, and by the re-action of the sulphureous principle upon the iron which the pyrites contains, and with which the acid of the sulphur forms martial vitriol, as we may see under the article PYRITES. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and exposed to the air during three years, till it has entirely fallen into powder; and it is then to be stirred up every six months to accelerate the efflorescence. The rain-water, which has washed it, is to be conducted into caldrons, into which old iron is thrown to saturate the superfluous acid. After this succeeds the evaporation and crystallization.

It is not necessary that the pyrites should fall into efflorescence for the extraction of vitriol. The action of the fire which decomposes one part of the sulphur produces the same effect. Thus, in the works at Scharitzberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the distillation of the sulphur, which is called in some works, as we have before said, the *burnings of sulphur*, and which are in this work called *sulphur-brands*. This operation consists in impregnating well the lixivium with vitriol, by pouring it upon fresh parcels of these sulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *sulphur-caldron*; and afterwards it is crystallized in a wooden vessel. The sulphur-brands, from which vitriol has been extracted, are not thereby exhausted; but they are exposed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is also made at Geyer, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been used for the extraction of sulphur by distillation, but has been roasted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in shallow tubs called coolers, where it deposits a yellow mud. The evaporation and depuration of this lixivium last twenty-four hours, and then the liquor is put into tubs to crystallize.

The pyrites, which has been roasted and lixiviated once at Geyer, is not thereby exhausted; but is made to undergo the same operation four or five times, by which it furnishes more vitriol. The yellow mud which is deposited from the lixivium is sold, as a coloring material, to painters, after it has been calcined to redness.

Nature furnishes a vitriol ready formed in some mineral waters, to obtain which vitriol, nothing but lixiviation is necessary. Such is that vitriol obtained at Cremnitz,



Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpose of preparing aqua fortis, which is necessary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a soft rock and clay are found, containing vitriol, and which furnish it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goslar by the lixiviation of a mineral earth, composed of particles of different ores, found in the galleries of the mine at Rammelsberg, of which we have already spoken. The workmen call this substance the *smoke of copper*. It requires lixiviation only to furnish vitriol. It is true, that by the wood-fires made in these galleries to calcine the rocks, the metallic matters may be disengaged, and a part of the sulphur burnt, the acid of which, mixing with the subterranean waters, dissolves all the metallic matters it meets, and forms all kinds of vitriols. Nevertheless, some of these vitriolic waters, and even some crystallized vitriols, are found in these galleries, where no fire is ever made. The Germans call all these vitriols by the general name *Jockels*. Some vitriols are also found not crystallized, but forming various colored stones, which furnish vitriol by lixiviation. They are called *ink-stones*. What is called *misy* is a yellow, shining, vitriolic stone or earth, found in the same places.

To return to the substance called *smoke of copper*, whence the martial vitriol is extracted at Goslar, several lixiviums are made of it, by pouring the same water upon different parcels of it: it is then made to evaporate, to deposit its sediment, and to crystallize, as we have already said. The first water is called the *wild lie*. The several vessels employed at Goslar are named from their several uses, as the *washing tub*, *mud tub*, &c.

This substance remaining after the lixiviation of this *smoke of copper*, is a kind of ore not entirely deprived of metallic substances. The workmen call the finest part of it *small vitriol*, and the larger pieces they call *stones*, or *kernels of vitriol*. Both these are carried to the smelting-houses to be roasted and melted with the Rammelsberg ore, that the lead and silver, which they contain as well as that ore, may be extracted.

A white vitriol, whose basis is zinc, is also procured at Goslar from the same Rammelsberg ore. This vitriol was discovered in the year 1570 by the Duke Julian, who called it *alum of the mine*. At present it is known by the names, *white vitriol*, *vitriol of zinc*, *Goslar vitriol*.

To make this vitriol, the ore of Rammelsberg, containing lead and silver, having been previously roasted for the obtaining of sulphur, as we have already described, undergoes the same operations which are practised for the preparation of martial vitriol, excepting the formation of large crystals, which is here purposely prevented, by liquifying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the crystallization of the vitriol. While the vitriol is liquefied, a part of the moisture is evaporated, and women employed in this work keep stirring it all it has acquired the requisite consistence. By this stirring, it is divided into very fine crystalline particles, and it acquires the whiteness of the finest sugar; a quality which makes it saleable, and which is procured by the means above related, and by carefully washing it deposits the ferruginous matter with which these lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from sulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals also contain copper; and therefore the vitriol extracted from them is half martial and half cupreous, and is of a sea-green color.

## EXTRACTION of ALUM from PYRITOUS SUBSTANCES and from ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and sulphureous minerals, is sometimes of that kind of earths which are soluble in acids, and particularly of the nature of that earth which is the basis of alum.

When the pyrites contains some of this kind of earth, the acid of its sulphur being disengaged either by the effluence of the pyrites, or by its calcination and combustion, ought to unite itself as readily, and even more so, to this earth than to the metals contained in the same pyrites, and form a true alum: accordingly it so happens, and alum is extracted from pyrites or other sulphureous minerals containing this earth, by processes similar to those employed for the extraction of vitriols.

In England, a pyritous, slate-colored, sulphureous stone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of fossil alkali, dissolved in water, is generally added.

The Swedes have a shining pyrites of a golden color, and speckled with silvery spots, from which they extract sulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have described; and when the lixivium yields no more crystals of vitriol, an eighth part of putrefied urine and lixivium of woodashes is added, by which a martial earth is precipitated: the liquor being poured off, crystals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from sulphureous and metallic minerals, fine and pure crystals cannot be without some difficulty obtained. It is almost always necessary to have recourse to some addition of alkaline matters, such as quicklime, and fixed or volatile alkaline salts.

These difficulties proceed partly from this, that different kinds of salts are formed at the same time by the decomposition of these minerals; and that these salts are crystallized by nearly the same degrees of evaporation and cold. Hence a confusion of salts must necessarily follow: and hence we do not find many of the vitriols, extracted from such minerals, perfectly pure and free from alum, or from vitriolic salts with earthy basis similar to alum. The *gilla vitrioli* and the *gilla vitrioli* are nothing else than these foreign salts. On the other hand, the alum which is extracted from metallic minerals contains, almost always some vitriol, and particularly martial vitriol.

(k) From Mr. Margraaf's experiments, it appears that, when alum is from the pyrites, or other an addition of some alkaline substance seems to be always necessary to the formation of large crystals of alum, however free the lixivium is from vitriol. (See a note (f) published in the article on Alum (Rome).)

But there are unmetallic earths and stones which contain alum, or its materials, ready formed. Such is that earth whence alum is extracted at Solfatara. This mineral is an earth similar to marle in consistence and color. It is gathered in the plain, and in the western part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till these vessels be three quarters full. The caldrons are sunk so as to be almost level with the ground, under a great hangar or shed, at a distance of four hundred paces from the sulphur furnaces. Into each caldron water is poured till it rise three or four inches above the mineral. The heat of the ground in this place is sufficient to warm the matter, as it makes Mr. Reaumur's thermometer rise to  $37\frac{1}{2}$  degrees above the freezing point. By this means, without the expence of wood, the saline part is separated from the earthy, and is obtained in large crystals.

Alum in this state is still mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is dissolved by hot water in a great stone vessel in form of a funnel. The purification of alum may be made to much more advantageously in this place, as no wood is necessary, the natural heat of the place being sufficient for the process.

To this kind of natural alum may be referred that which is obtained merely by evaporation from some mineral waters; and also the Roman alum which is obtained from a kind of free-stone, although a calcination during twelve or fourteen hours, and an exposition to the air till it falls into efflorescence be necessary. This stone is not pyritous, but rather of the marle kind: therefore its efflorescence is probably nothing more than an extinction, and differs essentially from the efflorescence of pyrites.

Such are the processes by which sulphur, vitriol, and alum are obtained from minerals containing these substances.

These minerals contain a great quantity of vitriolic acid, which chemists can separate from them; and they are, as it were, the grand magazines where nature deposits this acid, which is always found combined, as we have seen, with some substance or basis.

### *S M E L T I N G of O R E S in general.*

As ores consist of metallic matters combined with sulphur and arsenic, and are besides intermixed with earthy and stony substances of all kinds, the intention of all the operations upon these compound bodies is to separate these different substances from each other. This is effected by several operations founded on the known properties of those substances. We now proceed to give a general idea of these several operations.

First of all, the ore is to be separated from the earths and stones accidentally adherent to it; and when these foreign substances are in large masses, and are not very intimately mixed in small particles with the ore, this separation may be accomplished by mechanical means. This ought always to be the first operation, unless the adherent substance be capable of serving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this must necessarily be broken and divided into small particles. This operation is performed by a machine

machine which moves pestles, called bocards, or flampers. After this operation, when the parts of the mineral are specifically heavier than those of the unmetallic earth or stone, these latter may be separated from the ore by washing in canals through which water flows. With regard to this washing of ores, it is necessary to observe that it cannot succeed but when the ore is sensibly heavier than the foreign matters. But the contrary happens frequently, as well because quartz and spar are naturally very ponderous, as because the metallic matter is proportionably so much lighter as it is combined with more sulphur.

When an ore happens to be of this kind, it is necessary to begin by roasting it, in order to deprive it of the greatest part of its sulphur.

It happens frequently that the pyritous matters accompanying the ore are so hard that they can scarcely be pounded. In this case it is necessary to roast it entirely, or partly, and to throw it red-hot into cold water; by which the stones are split, and rendered much more capable of being pulverised.

Thus it happens very frequently, that roasting is the first operation to which an ore is exposed.

When the substance of the ore is very fusible, this first operation may be dispensed with, and the matter may be immediately fused without any previous roasting, or at least with a very slight one. For, to effect this fusion, it is necessary that it retain a certain quantity of its sulphur, which, with the other fluxes added, serves to destroy or convert into scoria a considerable part of the stoney matter of the mineral, and to reduce the rest into a brittle substance which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore an intermediate matter betwixt the mineral and the metal; for the metal is there concentrated, and mixed with less useless matter than it was in the ore. But as this matt is always sulphureous, the metal which it contains cannot have its metallic properties. Therefore it must be roasted several times to evaporate the sulphur, before it is remelted, when the pure metal is required. This fusion of an ore not roasted, or but slightly roasted, is called *crude fusion*.

We may here observe upon the subject of washing and roasting of ores, that as arsenic is heavier than sulphur, and has nearly the weight of metals, the ores in which it prevails are generally very heavy, and consequently are susceptible of being washed, which is a great advantage. But on the other side, as arsenic is capable of volatilising, scorifying, and destroying many metals, these ores have disadvantages in the roasting and fusion, in both which considerable loss is caused by the arsenic. Some ores contain, besides arsenic, or volatile semi-metals, such as antimony and zinc. These are almost untractable, and are therefore neglected. They are called *mineral vapours*, rapacious ores.

When the metal has been freed as much as is possible from foreign matters by these preliminary operations, it is to be completely purified by fusions more or less frequently repeated; in which proper additions are made, either to absorb the rest of the sulphur and arsenic, or to complete the vitrification or calcination of the unmetallic stones and earth.

Lastly,

Lastly, as ores frequently contain several different metals, these are to be separated from each other by processes suited to the properties of these metals, of which we shall speak more particularly as we proceed in our examination of the ores of each metal. (4)

(4) To facilitate the extraction of metallic substances from the ores and minerals containing them, some operations previous to the fusion or smelting of these ores and minerals are generally necessary. These operations consist of, 1. The *separation* of the ores and metallic matters from the adhering unmetallic earths and stones, by hammers, and other mechanical instruments; and by washing with water. 2. Their *division* or reduction into smaller parts by contusion and trituration; that by another washing with water they may be more perfectly cleansed from extraneous matters, and rendered fitter for the subsequent operations, calcination or roasting, and fusion. 3. *Roasting or calcination*, the uses of which operation are, to expel the volatile, useless, or noxious substances, as water, vitriolic acid, sulphur, and arsenic; to render the ore more friable and fitter for the subsequent contusion, and fusion; and, lastly, to calcine and destroy the vile metals; for instance, the iron or copper-ores, by means of the fire, and of the sulphur and arsenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red hot, and then extinguished in cold water, that they may be rendered sufficiently friable and pulverable, to allow the separation of the metallic particles.

Roasting is unnecessary for native metals; for some of the richer gold and silver-ores; for some lead-ores, the sulphur of which may be separated during the fusion; and for most calciform ores, as these do not generally contain any sulphur and arsenic.

In the roasting of ores, the following attentions must be given, 1. To reduce the mineral previously into small lumps, that the surface may be increased; but they must not be too small, nor placed too compactly, as to prevent the passage of the air and flame. 2. The larger pieces must be placed at the bottom of the pile, where the greatest heat is. 3. The heat must be gradually applied, that the sulphur may not be melted, which would greatly retard its expulsion; and that the iron, stone, and stones, intermixed with the ore, may not crack, fly and be dispersed.

4. The ores not thoroughly roasted by one operation must be exposed to a second. 5. The fire may be increased towards the end, that the noxious matters more strongly adhering may be expelled. 6. Fuel which yields much flame, as wood and fossil coals free from sulphur, is said to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, these being very various according to the difference of the ores. A roasting during a few hours or days is sufficient for many ores; while some, such as the ore of Rammelsberg, require that it should be continued during several months.

Schlutter enumerates five methods of roasting ores. 1. By constructing a pile of ores and fuel placed in alternate strata, in the open air, without any furnace. See PLATE II. Fig. 11. and Fig. 12. 2. By confining such a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace consisting of walls and a roof. 5. By roasting the ore in a reverberatory furnace, in which it must be continually stirred with an iron-rod.

Several kinds of *fusions of ores* may be distinguished. 1. When a sulphureous ore is mixed with much earthy matter, from which it cannot be easily separated, by mechanical operations, it is frequently melted, in order to disengage it from these earthy matters, and to concentrate its metallic contents. By this fusion, some of the sulphur is dissipated, and the ore is reduced to a state intermediate between that of ore and of metal. It is then called a *matte* (*lapis sulphureo-metallicus*), and is to be afterwards treated like a pure ore by the second kind of fusion, which is properly the *fusion, or extraction of the metal by fusion*. 2. By this fusion or smelting, the metal is extracted from the ore previously prepared by the above operations, if these be necessary. The ores of some very fusible metals, as of bismuth, may be smelted by applying

## OPERATIONS on ORES of NATIVE GOLD and SILVER, by WASHING and by MERCURY.

Earths and sand are at first separated by washing with water, by which operation the greatest part of what is not gold, being lighter, is carried off. After this a second washing is made with mercury, which having the property of uniting with gold, seizes this metal, amalgamates with it, and separates it exactly from the earthy matters, with all which it can form no union.

applying a heat sufficient only to melt the metals, which are thereby separated from the adhering extraneous matters. This separation of metals by fusion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a complete fusion of the ore and vitrification of the earthy matters are necessary for the perfect separation of the contained metals. By this method, metals are obtained from their ores, sometimes pure, and sometimes mixed with other metallic substances, from which they must be afterwards separated; as we shall see, when we treat of the extraction of particular metals. To procure this separation of metals from ores, these must be so thinly liquefied, that the small metallic particles may disengage themselves from the scoria; but it must not be so thin as to allow the metal to precipitate before it be perfectly disengaged from any adhering extraneous matter, or to pervade and destroy the containing vessels and furnaces. Some ores are sufficiently fusible; but others require certain additions called *fluxes*, to promote their fusion, and the vitrification of their unmetallic parts; and also to render the scoria sufficiently thin to allow the separation of the metallic particles.

Different fluxes are suitable to different ores, according to the quality of the ore, and of the matrix, or stone adherent to it.

The matrixes of two different ores of the same metal frequently serve as fluxes to each other; as, for instance, an argillaceous matrix with one that is calcareous; these two earths being disposed to vitrification when melted, tho' each of them is singly infusible. For this reason, two or more different ores to be fused, are frequently mixed together.

The ores also of different metals require different fluxes. Thus calcareous earth is found to be best suited to iron-ores, and spars and scoria to fusible ores of copper.

The fluxes most frequently employed in the smelting of ores are, calcareous earth, fluors or vitreous spars, quartz and sand, fusible stones, as flates, basaltes, the several kinds of scoria, and pyrites.

*Calcareous earth* is used to facilitate the fusion of ores of iron, and of some of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with felspar. This earth has been sometimes added with a view of separating the sulphur, to which it very readily unites: but by this union, the sulphur is detained, and a hear is formed, which readily dissolves iron and other metals, and so firmly adheres to them, that they cannot be separated without more difficulty than they could from the original ore. This addition is therefore not to be made till the sulphur be previously well expelled.

*Fluors or fusible spars* facilitate the fusion of most metallic minerals, and also of calcareous, and argillaceous earths, of steatites, asbestos, and of some other infusible stones, but not of siliceous earths without a mixture of calcareous earth.

*Quartz* is sometimes added in the fusion of ferruginous copper ores, the use of which is said chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous scoria.

The *fusible stones*, as *flates*, *basalts*, are so tenacious and sticky when fused, that they cannot be considered properly as fluxes, but as matters added to lessen the too great liquidity of some very calcareous materials.

The *scoria* obtained in the fusion of an ore is frequently added to facilitate the fusion of an ore of the same metal; and sometimes even of ores of different metals.

*Sublimed* or *burnt* greatly increases the fusibility of the scoria of metals, tho' the sulphur it contains, being easily set to

difficulty

The mercury thus charged with gold is pressed through shamoy leather, and the gold is retained united with a part of the mercury, from which it may be easily disengaged by exposure to a proper degree of heat, which dissipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. These operations consist in washings, triturations, and amalgams in the great by help of machines. We shall not enter into these details, because they rather belong to mechanics than to chemistry. They who are desirous to know them, may consult a work written by Alonzo Barba on this subject.

The ores of native silver are much rarer and less abundant than those of gold. But if any of this kind were found sufficiently rich, they might be treated with mercury exactly in the same manner as the ores of native gold. (*m*)

difficultly fusible copper-ores, to form the sulphureous compounds called *matts*, that the ores thus brought into fusion may be separated from the adhering earthy matters, and that the ferruginous matter contained in them may be destroyed, during the subsequent calcination and fusion, by means of the sulphur.

As in the ores called *calciform*, the metallic matter exists in a calcined state; and as calcination reduces the metals of mineralised ores (excepting the perfect metals) to that state also; therefore all calciform and calcined ores require the addition of some *inflammable substance*, to furnish them with the phlogiston necessary for their reduction to a metallic state. In great works, the charcoal or other fuel used to maintain the fire produces also this effect.

*Metals* are sometimes added in the fusion of ores of other more valuable metals, to absorb from these sulphur or arsenic. Thus iron is added to sulphurated, cupreous, and silver ores. Metals are also added in the fusion of ores of other more valuable metals, to unite with and collect the small particles of these dispersed through much earthy matter, and thus to assist their precipitation. With these intentions, lead is frequently added to ores and minerals containing gold, silver, or copper.

*Ores of metals* are also sometimes added to assist the precipitation of more valuable metals. Thus antimony is frequently added to assist the precipitation of gold intermixed with other metallic matters. See *purification of gold by antimony*. Thus far of smelting of ores in general.

(*m*) Gold is frequently contained in the ores of other metals, either in a native or

mineralised state, and in sands, especially those which are black and ferruginous. See ORES of GOLD.

If gold be contained in ores of other metals, these metals together with the gold may be first extracted by the ordinary process for smelting these ores; and the gold may be then separated from the metallic mass thus obtained, by mixing and fusing this mass with a quantity of lead, and by the process of cupellation, described in the articles ESSAY of the VALUE of SILVER, and REFINING. Generally, the operations for obtaining gold from ores of imperfect metals are precisely the same as those for obtaining silver, to which therefore we refer. Most frequently a quantity of silver also is contained in these ores; and in this case the perfect metal obtained by cupellation is an alloy of gold and silver, which must be afterwards separated by the processes called *parting*. See PARTING.

Many trials have been made to procure the small quantity of gold contained in the *ferruginous sands*, at a moderate expence (See ORES of GOLD); but as no work of this kind is now established, we may presume they have not been successful. The best essays of this kind have been made, according to Schlutter, in the following manner.

The sand is to be made red-hot, and extinguished in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddish brown. It is observed to emit, during the first and second calcinations, an arsenical smell; and this smell may be produced again in the following calcinations by adding some inflammable matter. Let an ounce of the calcined sand be mixed with two ounces of

U u u u granulated

## SMELTING of ORES of SILVER.

As silver, even in its proper ores, is always alloyed with some other metals from which it is intended to be separated, after that the silver ore has been well roasted, it must be mixed with a greater or less quantity of lead previous to its fusion.

Lead has the same effect in fusion of gold and silver as mercury has upon these metals by its natural fluidity; that is to say, it unites with them, and separates them from unmetallic matters, which, being lighter, rise always to the surface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic substances, excepting gold and silver. Hence it follows, that when gold and silver are obtained by means of mercury, they still remain alloyed with other metallic substances; whereas when they are obtained by fusion and scorification with lead, they are then pure, and are not alloyed with any metals but with each other.

In proportion as the lead, which has been united to the gold and silver of the ore, is scorified by the action of the fire, and promotes the scorification of the other metallic matters, it separates the perfect metals, and carries with it all the others to the surface. There it meets the unmetallic substances, which it likewise vitrifies, and which it changes into a perfect scoria, fluid, and such as a scoria ought to be to admit all the perfect metal contained in it to precipitate.

When all heterogeneous matters have been thus disengaged by scorification with lead, the perfect metals, to which some lead still remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fusion and scorification of silver ore with lead, is to add to the ore a quantity of lead so much greater as there is more matter to be scorified, and as these matters are more refractory and of more difficult fusion. Silver ores, or those treated as such, are often rendered refractory by ferruginous

granulated lead, and one ounce of black flux, and put into a Hessian crucible, with half an ounce of decrepitated sea-salt upon the surface of the mixture. The crucible is to be placed in a good blast furnace, and a strong fire is to be excited. The matter contained in the crucible is to be frequently stirred with an iron-rod, and the heat is to be continued till the scoria is thin and perfectly fused. When the crucible is broken, a regulus of lead will be found, containing the gold and silver of the sand. By this method Mr. Leberecht obtained, in eleven essays, from 840 to 844 grains of perfect metal from a quintal of sand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of sand have yielded more than a thousand grains, and some not more than 350 grains per quintal. Instead of the granulated lead, and the black

flux, which is too expensive for great operations, some have added, to an ounce of the sand, two ounces of litharge and a little powder of charcoal, by which they have obtained the same quantity of perfect metal. The scoria in these essays has been always found to contain some perfect metal.

The Hungarian copper ores, from which gold and silver are profitably extracted, contain a less quantity of these perfect metals than many ferruginous sands. But they may be formed into a matt, by fusion with pyrites, of which treatment the sands are incapable. From this matt, the gold and silver, along with the copper of the ore, may be precipitated, and separated from the sulphur of the pyrites, by addition of iron, which being more disposed than the other metals to unite with sulphur, disengages these metals, and allows them to precipitate.

carths,



earths, pyritous matters, or cobalts, containing always a considerable quantity of an earth which is unmetallic, very subtle, and very refractory, and which renders a considerable augmentation of the quantity of lead necessary.

The quantity of lead which is commonly added to fusible silver-ores, that do not contain lead, is eight times the quantity of the ore. But when the ore is refractory, it is necessary to add twelve times the quantity of lead, and even more; also glass of lead, and fluxes, such as the white and black fluxes; to which, however borax and powder of charcoal are preferable, on account of the liver of sulphur formed by these alkaline fluxes.

It is necessary to observe, that saline fluxes are only used in small operations, on account of their dearth. To these are substituted, in the great operations, of which we now treat, sandiver, fusible scoria, and other matters of little value.

The greatest part of the silver now employed in commerce is not obtained from the proper ores of silver, which are very scarce, but from lead, and even copper-ores, which are more or less rich in silver. To give an idea of the manner of treating these kinds of ores, from which silver is extracted in the great works, we shall briefly describe here, after Schlutter, the smelting of the ore of Rammelsberg, which contains, as we have already said, several different kinds of metals, but particularly lead and silver.

When this mineral has been disengaged from its sulphur as much as possible, by three very long roastings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for smelting upon a hollow or *casse*. See PLATE II. Fig. 13. The masonry of this furnace is composed of large, thick slates, capable of sustaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only in the front. Its height is nine feet eight inches. It has a foundation of masonry in the ground; and, in this foundation channels are made for the evaporation of the moisture. These channels are covered over with stones called *covering stones*. The hollow or *casse*, which is made above these, is formed of bricks, upon which are placed, first, a bed of clay; then a bed of small ore and sifted vitriols; and, lastly, a bed of charcoal-powder beat down, called *light brasque*. The anterior wall of the furnace is thinner than the others, and is called the *chemise*. The back wall, which is pierced to give passage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or *casse*; which being kindled, the fire is to be continued during three hours, before the matters to be fused are added. Then these matters are thrown in, which are not the pure ore, but a mixture of several substances, all of which are somewhat profitable. The quantity of these matters is sufficient for one day's work; that is for a fusion of eighteen hours; and it consists of; 1. Twelve schorbens or measures of well roasted Rammelsberg ore; (the schorben is a measure whose contents are two feet five inches long, one foot seven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologne weight, at 123 pounds each quintal). 2. Six measures of scoria produced by the smelting of the ore of Upper Hartz, which is refractory, and what workmen call *cold*. 3. Two measures of *knobben*, which is an impure scoria containing some lead and silver,

which has been formerly thrown away as useless, and is now collected by women and children. Besides these, other matters are added, containing lead and silver, as the tests employed in refining, the drops of lead, impure litharge, and any rubbish containing metal, which was left in the furnace after the foregoing fusion. All these matters being mixed together are thrown into the furnace: And to each measure of this mixture a measure of charcoal is added. The fusion is then begun by help of bellows; and as it proceeds, the lead falls through the light braque or charcoal bed, into the hollow, or cast, where it is preserved from burning under the powder of charcoal. The scoria, on the other hand, being lighter and less fluid, is skimmed off from time to time by means of ladders, that it may not prevent the rest of the lead from falling down into the hollow. Thus, while the fusion lasts, fresh matters and fresh charcoal are alternately added, till the whole quantity intended for one fusion, or, as they call it, one *day*, be thrown in.

There are several essential things to be remarked in this operation, which is very well contrived. First, the mixture of matters from which a little lead and silver is procured, which would otherwise be lost; and which have also this advantage, that they retard the fusion of the Rammelsberg ore, which, however well roasted it has been, retains always enough of the sulphur and iron of the pyrites mixed with it, to render it too stiff or too fluid, so that without the addition of those matters, nothing would be obtained but a matt. It is even necessary, notwithstanding these additions, not to hasten the fusion too much, but to give time for the ore to mix with the other matters, else it would melt and flow of itself before the rest. Secondly, the fusion of the ore through charcoal, which is practised in most smelting-houses and for almost all ores, is an excellent method, the principal advantage of which is the saving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the same time that it melts it more readily and completely, also supplies it with the phlogiston necessary to bring it to a perfect stage.

We mentioned, when treating of vitriols obtained from the Rammelsberg ore after its first roasting, that a *white vitriol* was also obtained, and prepared at Goslar, whose basis was *zinc*: which proves that this ore contains also a certain quantity of this semi-metal. As this ore is smelted in a country where the art is well understood of extracting every thing which a mineral contains, so in this fusion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fusion, it is necessary to close it up in the fore-part, before the fusion is begun.

“ First of all, a gritt-stone is to be placed, supported at the height of three inches. This stone is as long as the furnace is broad, and the height of it is level with the hole where the bellows pipe enters. It is fastened on each side of the furnace, externally and internally, with clay. Upon this stone a kind of receptacle, or, as it is called, the *seat of the zinc*, is made in the following manner. A flat, flaty stone is chosen, likewise as long as the furnace is broad, and eight inches in breadth. This is placed on the gritt-stone above-mentioned, in such a manner, that it inclines considerably towards the front of the furnace, and that its bottom touches closely the gritt-stone. It is fastened with clay, which is also laid upon the seat of the zinc. Upon this seat, which is to receive the zinc, two round pieces of charcoal are placed, and upon these

“ these a stone, called the *zinc stone*, rests, which is about a foot and a half in length, and closes one part of the front of the furnace. This stone also is fastened on each of its sides with clay. Clay is likewise put under the stone betwixt the two pieces of charcoal, which hinder it from touching the seat of the zinc. The under part of this stone is but slightly luted, that the workmen may make an opening for the zinc to flow out. Thus is made the seat or receptacle of the zinc to detain this metallic substance, which would otherwise fall into the hottest part of the fire, called by the workmen the melting place, and would be there burnt: whereas it is collected upon this receptacle during the fusion, where it is sheltered from the action of the bellows, and consequently from too great heat.

“ When all the matter to be fused in one day is put into the furnace, the blast of air is continued till that matter has sunk down. When it is half way down the furnace, they draw out the scoria, that more of the ore and other matters may be exposed to the greatest heat. As soon as the scoria is cooled and fixed a little, two shovel-fulls of small wet scoria or sand is thrown close to the furnace, and beat down with the shovel; then the workmen open the seat or receptacle of zinc, and strike upon the zinc-stone to make the fern metal flow out. As soon as the purest part of it has flowed out, it is sprinkled with water and carried away. Then the workmen separate entirely the zinc-stone from the wall of the furnace, and they continue to give it little strokes, that the small particles of zinc dispersed among the charcoal may fall down. This being done, the stone is removed, and the zinc is separated from the charcoal by an iron instrument is cleaned, and remelted along with the zinc that flowed out at first, and is cast into round cakes. The reason why the zinc is withdrawn before the bellows cease to blow, is, that if it were left till the charcoal on the seat or receptacle was consumed, it would be mostly burnt, and little would be obtained. Thus after the zinc fusion is finished by blowing the bellows till the end.”

Thus the zinc is separated from the ore of Rammelsberg, and is not confounded in the scoria or casse with the lead and silver, because being a volatile semi-metal. It cannot support the activity of the fire without rising into vapors, which are condensed in the place least hot, that is to say, upon the stones expressly prepared for that purpose, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is also in this furnace, and after the fusion of the Rammelsberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is composed of sulphureous and ferruginous pyrites, of true lead ore containing silver, and a very hard and compact matter of a dark brownish-grey color, which is probably a lapis calaminaris, or an ore of zinc. These several matters of the Rammelsberg ore are not separated from each other, either for the roasting or for the fusion. Thus there is zinc in all the parts of the roasted ore, and much more of it would be obtained, if it was not so easily inflammable. All the zinc which is obtained is preserved from burning by falling, while in fusion, behind the chemise or forepart of the furnace, which is, as has been said, a kind of schistus or slate, called by the workmen *steel stone*. But the part of this semi-metal which falls in the middle of the furnace, near the middle wall,

or towards the sides, being exposed to the greatest heat of the fire, is there burnt; and its smoke or flowers attaching itself on all sides to the walls of the furnace, undergo there a semi-fusion, which renders this matter so hard and so thick that it must be taken away after every fourth fusion, or, at most, after every sixth fusion. That which is found attached to the highest part of the furnace is the best and purest. The rest is altered by a mixture of a portion of lead which it has carried up with it, and which from its great weight and fixity has hindered the zinc from rising so high as it would have done alone. Therefore with this kind of impure cadmia ductile brass cannot be made.

Almost all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelsberg ore, by the process described, and consequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fused for that purpose. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of brass, a convenient process for extracting zinc from it was not known, because when treated by fusion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fused without a very violent fire; and also from the volatility and combustibility of the zinc, which for this reason cannot be collected at the bottom of a crucible, as a regulus under a scoria, like most metals.

M. Margraaf has remedied these inconveniences by distilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing some water, and consequently in close vessels, where the zinc by the help of a very strong fire indeed, is sublimed in its metallic form without burning. He also by the same method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is also a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiston. But it is evident that such operations as these are rather fit to supply proofs for chemical theory, than to be put in practice for works in great (*n*). M. Margraaf has observed, that the zinc which he obtained by this process was less brittle than what is obtained from the fusion of ores; which may proceed from its greater purity, or from its better combination with phlogiston.

After this digression which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not insert elsewhere, because of the necessary relation it has with the smelting of the Rammelsberg ore, we proceed to the other operations of the same ore, that is to say, to the *finery*, by which the silver is separated from the lead, which are mixed together, forming what is called the *work*.

(*n*) ZINC is obtained not only in the method used at Goslar above-described, but is also extracted in great works from lapis calaminaris and calcined blend, by a distillation similar to that by which Mr. Margraaf has essayed ores of zinc. The first work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this

ore, when calcined, powdered, and mixed with charcoal, was put into iron or stone retorts, and the zinc was obtained by distillation. In Bristol a work is established in which zinc is obtained by a distillation *by descent*. See a section and description of the furnace and apparatus employed. PLATE II. Fig. 22. and explanation.

This

This operation differs from the fining of assay, or in small, principally in this circumstance, that in the latter method of fining, all the litharge is absorbed into the cupel, whereas in the former method the greatest part of this litharge is withdrawn.

The fining in great of the work of Rammelsberg is performed in a furnace called a *reverberatory furnace*. This furnace is so constructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air (which is introduced through the ash-hole, and which goes out at an opening on one side of that part of the furnace where the work—that is the lead and silver are)—to circulate above, and to give the convenient degree of heat, when the fire is properly managed. In this furnace a great cupel, called a *test*, is disposed. This test is made of the ashes of beech-wood, well lixiviated in the usual manner. In some foundaries different matters are added, as sand, spar, calcined gypsum, quicklime, clay. When the test is well prepared and dried, all the work is put at once upon the cold test, to the quantity of sixty-four quintals for one operation. Then the fire is lighted in the fire-place with faggots, but the fusion is not urged too fast; 1. That the test may have time to dry: 2. Because the work of the Rammelsberg ore is altered by the mixture of several metallic matters, which it is proper to separate from it, otherwise they would spoil the litharge and the lead procured from it. These metallic matters are, copper, iron, zinc, and matt. As these heterogeneous substances are hard and refractory, they do not melt so soon as the *work*, that is, as the lead and silver; and when the work is melted, they swim upon its surface like a skin, which is to be taken off. These impurities are called the *scum*, or the *first-waste*. What remains forms a second scum, which appears when the work is at its greatest degree of heat, but before the litharge begins to form itself. It is a scoria which is to be carefully taken off. It is called the *second waste*.

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very surface of the metal, by means of iron plates put for that purpose before the blast-hole, which are called *papillons*. This blast does not so much increase the intensity of the fire, as it facilitates the combustion of the lead, and throws the litharge that is not imbibed by the test towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace: the matter which is found in the middle of the largest pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like sand. This is put into barrels containing each five quintals of it, and is called *saleable litharge*, because it is sold in that state. The other part which remains solid is called *cold litharge*, and is again melted and reduced into lead. The fusion is called *cold fusion*, and the lead obtained from it, *cold lead*, which is good and saleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The tests and cupels impregnated with litharge are added in the fusion of the ore, as we have already related.

When two thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The silver then appears covered with a  
white

white skin, which the finers call *lightening*, and the metal, *lightened* or *fined silver*.

The silver obtained by this process of fining is not yet altogether pure. It still contains some lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who complete its purification by the ordinary method. This last operation is the *refining*, and the workmen employed to do it are called *refiners*. A fining of sixty four quintals of *work*, yields from eight to ten marcs of fined silver, and from 35 to 40 quintals of litharge; that is, from 12 to 18 of saleable litharge, from 22 to 23 of cold litharge, from 20 to 22 quintals of impregnated test, and from six to seven quintals of lead-drops. The operation lasts from 16 to 18 hours. (o)

(o) Ores containing silver may be divided into four kinds; 1. *Pure*, or those which are not much compounded with other metals. 2. *Galénical*, in which the silver is mixed with much *galena* or ore of lead mineralised by sulphur. 3. *Pyritous*, in which the silver is mixed with the martial pyrites. 4. *Cupreous*; in which the silver is contained in copper-ores. To extract the silver from these several kinds of ores, different operations are necessary.

*Native silver* is separated from its adhering earths and stones by amalgamation with mercury, in the manner directed for the separation of gold; or by fusion with lead, from which it may be afterwards separated by cupellation.

*Pure ores* seldom require a previous calcination, but, when bruised and cleansed from extraneous matters, may be fused directly, and incorporated with a quantity of lead; unless they contain a large proportion of sulphur and arsenic; in which case a calcination may be useful. The lead employed must be in a calcined or vitrified state, which, being mixed with the ore, and gradually reduced by the phlogiston of the charcoal added to it, may be more effectually united with the silver of the ore, than if lead itself had been added, which would too quickly precipitate to the bottom of the containing vessel or furnace. The silver is to be afterwards separated from the lead by cupellation.

*Galénical ores*, especially those in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fused together with some inflammable matter, as charcoal, by which the lead is

revived, and, together with the silver, is precipitated.

*Pyritous ores* must be first melted, so as to form a matt. If the sulphur is not sufficient for this kind of fusion, more sulphurated pyrites may be added. This matt contains, besides silver and sulphur, also various metals, as lead, iron, and sometimes cobalt. The matt must be exposed to repeated calcinations till the sulphur is dissipated. By these calcinations most of the iron is destroyed. The calcined matt is to be fused with litharge, and the silver incorporated with

from the other imperfect metals with which it may be mixed, it must afterwards be separated by cupellation. See REFINING.

The silver contained in *cupreous ores* may be obtained, either, 1. By separating it from the copper itself, after this has been extracted along with the silver, in the usual manner, from the ore; or, 2. By precipitating it immediately, from the other matters of the ore.

1. It may be separated from the copper by two methods. One of these is by adding lead, and scorifying the imperfect metals. By this method much of the copper would be destroyed, and it is therefore not to be used unless the quantity of silver relatively to the copper be considerable. Another method by which silver may be separated from copper is, by *eliquation*; that is, by mixing the mass of copper and silver with a quantity of lead, and applying such a heat as shall be just sufficient to make the lead *eliquate* from the copper, together with the silver, which being more strongly disposed to unite with the lead than with the copper, is thus incorporated with the former metal, and separated

## SMELTING of ORES of COPPER.

The smelting in great of copper ores, and even of several ores of silver and lead, excepting that of Rammelsberg, is performed in furnaces not essentially different from that already described; but in this respect only, that the scoria and metal are not drawn out of the furnace, but flow spontaneously, as soon as they are melted, into *receiving basins*, where the metal is freed from the scoria. These furnaces are generally called *pierced furnaces*.

Instead of a light brasque, or bed of charcoal-powder, under which the metal lies hid, the bottom of these furnaces is covered with a basin composed of heavy brasque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemise, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving basins*, made of earth, scoria, sand, &c. There the metal is separated from the scoria, by making it flow from these basins into another lateral one. These furnaces are also called *crooked furnaces*.

Different names are given to them according to some difference in their construction. For instance, those which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two basins, are called *spectacle-furnaces*. Their greater or less height gives occasion also to the distinction of *high furnaces*, and *middle furnaces*.

The high furnaces are of modern invention. They were first introduced at Mansfeldt in the year 1737, and they are now used in almost all countries where ores are smelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage consists in simplifying and diminishing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hottest part of the fire, and is melted. Consequently, it suffers successively different degrees of heat, and, before it is melted, it undergoes a roasting which costs nothing; therefore the high furnaces

rated from the latter. See the article ELIQUATION.

2. Silver may also be extracted from these cupreous ores by *reduction*. For this purpose, let the ore, previously bruised and cleaned, be formed into a mass, that the earthy matter may be well separated. Let this mass be covered with a strong hearth, and when the heat is at its greatest, and the heat is increased, with fire, let the clean galena, litharge, and granulated lead, when the fire has been raised, and the substances well separated, with the addition of some salt, be added to the mass, and the mass is to unite with the silver, with the zinc, and to separate the latter matter and along with

it the silver or gold contained in the matt. This method was introduced by Scheffer, and is practised at Adelfors in Smoland. In this work the proportion of the several materials is, four quintals of matt, two quintals of black copper containing some lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of cast iron.

The silver is thus, and in all other instances where it is united with lead, is to be afterwards separated from the lead by cupellation, which process is described at the article, ESSAY of the VALUE of SILVER, and Refining.

are chiefly employed for crude fusions, and particularly for the slate copper-ore. These furnaces are above eighteen feet high. A too great height is attended with an inconvenience, besides the trouble of supplying it with ore and fuel, which is, that the charcoal is mostly consumed before it gets down where the greatest heat is required, and is then rendered incapable of maintaining a fire sufficiently intense.

All the furnaces which we have mentioned are supplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for smelting ores where bellows are not employed, is what is called a *reverberatory furnace*. The Germans call it a *wind-furnace*. It is also distinguished by the name of *English furnace*, because the invention of it is attributed to an English physician of the name of *Wright*, who was well versed in chemistry; and because his use of it was first introduced in England about the end of the last century, where it is much employed, as well as in several other countries, as at Konigsberg, in Norway. See Plate III. figs. 14 and 15.

The length of these furnaces is about eighteen feet, comprehending the masonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raised three feet above the level of the masonry: on one side is the fire-place, under which is an ash-hole hollowed in the earth; on the other side is a bison made, which is kept covered with fire when there is occasion; on the anterior side of the furnace there is a chimney, which receives the flame after it has passed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of sustaining the fire. The advantage of this furnace is, that bellows are not necessary, and consequently it may be constructed where there is no current of water, and wherever the same happens to be. This furnace has a hole in its front through which the scoria is drawn out, and a door, as we have said, on one side, made with sand, in which are oblong tracks for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineralized, not only by sulphur and arsenic, but also by ferrometals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with sulphur and arsenic, it is almost impossible to disengage it from them entirely by melting; hence, in the smelting it gets, nothing is obtained by the first operation but a copper-matt, which contains all the principles of the ore, excepting the water and some parts, particularly when the ore is the best, crude, and unroasted. Afterwards the *matt* must be again roasted and fused. The product of this second fusion begins still more to resemble copper, but is not entirely so. It is a dark color, almost all the minerals, particularly with arsenic, and some with sulphur, of a black color, it is always called *black copper*, and so it is called, though ever its color happens really to be.

As, of all the imperfect metals, copper is most difficultly fused, and therefore it is again roasted several times, in order to burn off entirely the minerals which are mixed with it, and thus obtain all the copper which it contains, which is then called *raw copper*, and which is the best for the use of the smith, and refining of it. But copper is not always so pure, and sometimes it is found that these happened to be in the ore.





We shall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended

2. The iron of these ores is destructible by the burning sulphur during the roasting or the fusion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of smelting cupreous ores.

From these facts we learn, 1. That sulphur may be employed to separate and destroy iron mixed with copper; 2dly, that iron may be employed to separate the sulphur from copper, as is sometimes done in the assay of sulphurated copper-ores; and, 3dly, that by adjusting the proportion of the iron and sulphur to each other in the smelting of copper-ores, these two substances may be made to destroy each other, and to procure a separation of the copper; and this adjustment may be effected, by adding sulphur or sulphureous pyrites to the copper-ore, when the quantity of sulphur contained in this ore relatively to the iron is too small; or by adding iron when the sulphur predominates; or by roasting, by which the superfluous sulphur may be expelled, and no more left than is sufficient for the destruction of the iron contained in the ore. We shall apply these principles to the following cases.

1. When the quantity of sulphur and of iron in a copper-ore is small, and especially when the iron does not too much abound, a previous roasting will be once calcine the iron, and expell most of the sulphur; so that by one fusion the calcined iron may be scorified, and black-copper may be obtained. If the sulphur has not been sufficiently expelled, a second roasting and fusion are requisite; for the whole quantity of sulphur ought not to be expelled during the first roasting, but as much ought to be left as is sufficient for the scorification of the calcined iron, otherwise this might, during the fusion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the sulphur, some sulphurated pyrites, especially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and scorified.

3. When the quantity of sulphur and iron

iron is very great, that is, when the ore is very pyritous and poor, it ought to be first formed into a matt, by which it is separated from the adherent earths and stones, and the bulk is diminished; then, by repeated and alternate roastings and fusions, the copper may be obtained.

4. When the quantity of sulphur in an ore is greater than is sufficient for the forming a matt, the superfluous quantity ought to be previously expelled by roasting.

The copper thus at first obtained is never pure, but is generally mixed with sulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a small quantity of lead is added, which unites with the sulphur, and is scorified together with the iron, and floats upon the surface of the melted copper. This purification of copper by means of lead is similar to the refining of silver by cupellation, and is founded on the property of lead, by which it is more disposed to unite with sulphur than copper is, and on a property of copper, by which it is less liable than any other imperfect metal to be scorified by lead. But as copper is also capable of being scorified by lead, this operation must be no longer continued, and no more lead must be employed than is sufficient for the separation of the sulphur, and for the scorification of the iron.

The copper might also be purified from any remaining sulphur by adding a sufficient quantity of iron in charge, the sulphur. Thus Mr. Scheffer found, that by adding to sulphurated copper, from each stone of old cast iron, he rendered the copper pure.

For his *Experimentum in Purificando Cuprum*, Jan. 1752. In all iron added ought not to be too little, else all the sulphur will not be separated, and it ought not to be too great, else the superfluous quantity will unite with and injure the iron of the copper. The fusion and scorification, with addition of lead, seems to be the best method for the last purification of copper.

for this work. Besides, what remains to be said upon the ores of mercury, antimony, bismuth, arsenic, and cobalt, is already sufficiently explained in the different articles of this Dictionary relating to these substances, and to their products. The fusion in great of ores of iron would indeed particularly deserve to be treated more extensively, on account of its importance; but we observe, that the general principles of the smelting of ores contained in the present article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatises, which are not wanting on this subject, and particularly to the *Art of Forges and Iron-furnaces*, described most exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correspondent of that Academy; a work which makes part of a general description of the Arts undertaken by that illustrious company. (q)

(q) In this work, which pretends to treat of the principles of arts in general, we ought certainly not to omit some description of the methods of procuring and manufacturing a metal, so extensively useful, that without it no other art could have been perfected, and even, as some writers have observed, mankind could not have been civilized.

In the article *IRON*, the author of the Dictionary has described the chemical properties of that metal, or its effects when acted upon by fire, acids, and other substances. The subjects of this note and of the article *STEEL* are the processes by which iron is obtained from its ores, and reduced to the several states of *cast iron*, *forged iron*, and *steel*, and the properties of this metal in these several states, which render it fit for the various uses to which it is daily applied.

Notwithstanding the great importance of these subjects, and the labors of Reaumur, Swedenborgius, and of some other authors, we have still a very imperfect knowledge of the causes of the differences of the several kinds of ores, of the methods of smelting best adapted to these differences, of the causes of the good and bad qualities of different kinds of iron, and of the means of so improving this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very industriously and exactly described the different processes now used in most parts of Europe for the smelting of ores of iron, for the forging of that metal, and for the conversion of it into steel: but we do not find that he or any other author has, by experiments and discoveries, contributed much to the illustration or to the improvement of this part of

metallurgy, unless, perhaps, we except those of Mr. Reaumur, concerning the softening of cast iron by cementation with earthy substances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fusibility, in the methods necessary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Most ores require to be *roasted* previously to their fusion; some more slightly, and others with a more violent and longer-continued fire. Those which contain much sulphur, arsenic, or vitriolic acid, require a long-continued and repeated roasting, that the volatile matters may be expelled.

Some ores require a very slight roasting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others, which being in a calcined state, and containing no sulphureous or inflammable matter, would, by a further calcination, be rendered less capable of uniting with phlogiston, and consequently of being reduced to a metallic state.

Also the ores which are attractable by magnets, and which contain iron in a state nearly metallized, require little or no roasting.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, (*See PLATE II. Fig. 11. and 12.*), or in furnaces similar to those commonly employed for the calcination of lime-stone.

Some authors advise the addition of some calcareous earth to sulphureous ores during the roasting, that the sulphur may be absorbed.

DCXXXII. S N O W of A N T I M O N Y. The Bowers of regulus of antimony are so called. See FLOWERS of REGULUS of ANTIMONY.

forbed by this earth when converted into quicklime. But we may observe, that the quicklime cannot absorb the sulphur or sulphurous acid, till these be first extricated from the ore, and does therefore only prevent the dissipation of these volatile matters; and, secondly, that the sulphur thus united with the quicklime forms a hepar of sulphur, which will unite with and dissolve the ore during its fusion, and prevent the precipitation of the metal.

The next operation is the *fusion* or *smelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty feet high, in the bottom of which is a basin for the reception of the fluid metal. See a *Section and Description of this Furnace in PLATE II. Fig. 26, and the Explanation of that Figure.* When the furnace is sufficiently heated, which must be done at first very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limestone, or whatever other flux is employed. While the fuel below is consumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, sink gradually down, till they are exposed to the greatest heat in the furnace. There the ore and the flux are fused, the metallic particles are revived by the phlogiston of the fuel, are precipitated by means of their weight through the scoria formed of the lighter earthy parts of the flux and of the ore, and unite in the basin at the bottom of the furnace, forming a mass of fluid metal covered by a glassy scoria. When a sufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of sand, and thence into smaller lateral or connected channels, or other moulds. There it is cooled, becomes solid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called a *seu*, and those formed in the smaller channels are called

*pijs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of sand or of clay, and is thus formed into the various utensils and instruments for which cast iron is a proper material.

The *scoria* must be, from time to time, allowed to flow out, when a considerable quantity of it is formed, through an aperture made in the front of the furnace for that purpose. A sufficient quantity of it must, however, be always left to cover the surface of the melted iron; else the ore which would fall upon it, before the separation of its metallic from its unmetallic parts, would lessen the fluidity and injure the purity of the melted metal. This scoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a scoria, not sufficiently fluid, is always found to contain much metal. If the scoria be too thin, the metallic particles of the ore will be precipitated before they are sufficiently metallized, and separated from the earthy and unmetallic parts. A due degree of fluidity is given to the scoria by applying a proper heat, and by adding fluxes suited to the ore.

Some ores are fusible without addition, and others cannot be smelted without the addition of substances capable of facilitating their fusion.

The *fusion ore* are those which contain sulphur, arsenic, or are mixed with some fusible earth.

The *ore difficile fusile* are those which contain no mixture of other substance. Such are most of the ores which are attracted by magnet, and which contain iron in a state nearly metallic. As iron itself, when parted from all heterogeneous matters, is scarcely fusible without addition, so the metal contained in these pure kinds of ores cannot be sufficiently melted without the addition of some other substance. A scoria which are mixed with some very refractory substance. Some of these refractory ores contain arsenic, but as this substance facilitates the fusion of iron, we may presume that

DCXXXIII. S O A P. The name *saep* was formerly employed only to signify combinations of alkaline salts with oils, that is, compounds in which

that their refractory quality depends upon a mixture of some unmetallic earth or other unfusible substance.

Perhaps the fusibility of different ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; since we have reason to believe that, by a very perfect calcination, some metals, at least, may be reduced to the state of an earth almost unfusible, and incapable of that intimate union with phlogiston in which metallisation consists (*see the article METALS*); and since we know, that in every calcination and subsequent reduction of a given quantity of any imperfect metal, a sensible part of that quantity is always lost or destroyed, however carefully these operations may have been performed. If this notion be just, the most probable means of improvement in the smelting of ores of imperfect metals, especially of iron, seem to be by discovering some method of effecting the combination or intimate union of phlogiston with metallic earths or calxes, more completely and certainly than by immediately exposing them to a melting heat, in which those metallic particles only can be revived, that are already much disposed to metallisation. That some of these ores are already too much calcined, appears from the instance above-mentioned of the *big ores*, which are injured by roasting; and even the great height of the common smelting furnaces, although advantageous to many ores that require much roasting, is said to be injurious to those which are already too much calcined, by exposing them to a further calcination, during their very gradual descent, before they arrive at the hottest part of the furnace, where they are fused.

Further, when we consider how many instances occur of combinations which can be effected only by slow degrees, we have reason to hope, that methods of more effectually combining phlogiston with metallic earths may be discovered, by which a larger proportion of metal may be obtained from the ores, especially the calcareous ores of iron, and perhaps of other imperfect metals, than is now obtained by the methods commonly practised.

Various substances are added to assist the fusion of ores difficultly fusible. These are;

1. *Ores* of a fusible quality, or which, being mixed with others of a different quality, become fusible; accordingly, in the great works for smelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-short*, and another ore which produces iron brittle when cold, or *cold-short*, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as *cold-short* as iron obtained solely from one of the ores, and half as *red-short* as iron obtained only from the other ore.

2. *Earths and stones* are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous nature, limestone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous earth should be added; because these two earths, though singly unfusible, yet, when mixed, mutually promote the fusion of each other; but as limestone is almost always added in the smelting of iron-ores, and as in some of these, at least, no argillaceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fusion, not by uniting with an argillaceous earth, but by uniting with that part of the ore which is most perfectly calcined, and least disposed to metallisation; since we know, that by mixing a calcareous or roasted ore of iron with calcareous earth, without any inflammable matter, these two substances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron,*



oils are rendered miscible with water, by means of an alkali. But since chemists, by a more exact examination of the nature of bodies, have dis-

*by Mr. Brandt, in the Swedish Memoirs for the years 1749 and 1751.*

Some authors pretend, that a principal use of the addition of lime-stone in the smelting of iron-ores is to absorb the sulphur, or vitriolic acid, of these ores: but, as we have already observed, a heap of sulphur is formed by that mixture of calcareous earth and sulphur, which is capable of dissolving iron in a metallic state; and thus the quantity of metal obtained from an ore not sufficiently divested of its sulphur, or vitriolic acid, (which, by uniting with the phlogiston of the fuel, is formed into a sulphur during the smelting) must be considerably diminished, though rendered purer, by addition of calcareous earth: hence the utility appears of previously expelling the sulphur and vitriolic acid from the ore by a sufficient roasting. 3. The *scoria* of former smeltings is frequently added to assist the fusion of the ore; and, when the *scoria* contains much iron, as sometimes happens in ill conducted operations, it also encreases the quantity of metal obtained.

The quantity of these fusible matters to be added varies according to the nature of the ore; but ought in general to be such, that the *scoria* shall have its requisite degree of thinness, as is mentioned above.

The fuel used in most parts of Europe for the smelting of ores of iron is charcoal. Lately, in several works in England and Scotland, iron-ore has been smelted by means of pitcoal, previously reduced to cinders or *coaks*, by a kind of calcination similar to the operation for converting wood into charcoal, by which the aqueous and sulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France, pitcoal not calcined has been tried for this purpose, but unsuccessfully. The use of *peat* has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality and also upon the quantity of the fuel employed. Charcoal is better than *coaks* for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous, and other ores easily fusible, require less fuel than ores difficultly fusible. In general, if the quantity of fuel be too small, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the *scoria*, which will not be sufficiently thin. This defect of fuel may be known by the blackness and compactness of the *scoria*, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with *scoria*, smooth in its texture, without scales or grains, rough and convex in its surface, and liable to great loss of weight by being forged; and, lastly, it may be known by observing the color and appearance of the drops of metal falling down from the smelted ore, and of the *scoria* upon the surface of the fluid metal, both which are darker-colored than when more fuel is used. When the quantity of fuel is sufficiently large, and the heat is intense enough, the iron is darker-colored, denser, more tenacious, contains less *scoria*, and is therefore less fusible, and loses less of its weight by being forged. Its surface is also smoother and somewhat concave; and its texture is generally granulated. The *scoria*, in this case, is of a lighter color and less dense. The drops falling from the smelted ore and the liquid *scoria* in the furnace appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intense, the iron will appear to have a still darker color, and more conspicuous grains or plates, and the *scoria* will be lighter, whiter, and more spongy. The drops falling from the smelted ore, and the fluid *scoria*, will appear to a person looking into the furnace through the blast-hole to be very white and shining hot. The quantity of charcoal necessary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation skillfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumstances.

The time, during which the fluid metal ought to be kept in fusion before it is allowed to flow out of the

covered, that acids, and even other saline substances, may also be united with oils, and may render these miscible with water, they have generalised the name

the furnace must be also attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumstances, we cannot determine. In some works the metal is allowed to flow out of the furnace every six or eight, and in others only every ten or twelve hours. Some workmen imagine, that a considerable time is necessary for the concoction of the metal. This we are certain of, that the iron undergoes some change by being kept in a fluid state; and that if its fusion be prolonged much beyond the usual time, it is rendered less fluid, and also its cohesion, when it becomes cold, is thereby greatly diminished. The Marquis de Courtivron says, that the cohesion may be restored to iron in this state, by adding to it some vitrescible earth, which he considers as one of the constituent parts of iron, and which he thinks is destroyed by the fusion too long continued. That the fusibility of cast iron does depend on an admixture of some vitrescible earth, appears probable from the great quantity of scoria forced out of iron during its conversion into malleable or forged iron, and from the loss of fusibility which it suffers nearly in proportion to its loss of scoria. The quantity of iron daily obtained from such a furnace as we have described, is from two to five tons in twenty-four hours, according to the richness and fusibility of the ore, to the construction of the furnace, to the adjustment of the due quantity of flux and of fuel, and to the skill employed in conducting the operation.

The *quality of the iron* is judged by observing the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its surface is spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Mr. Reaumur says, that dark-colored cast iron is more impure than that which is white. The Marquis de Courtivron is of a contrary

opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle cast iron, sometimes ductile forged iron is produced. Cast iron with brilliant plates and points, when forged, becomes sometimes red short and sometimes cold-short. Large shining plates, large cavities called *eyes*, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold or red-short cannot be affirmed till it be forged. Whiteness of color, brittleness, closeness of texture, and hardness, are given to almost any cast iron by sudden cooling; and we may observe, that in general the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-colored iron is fitter for being cast into moulds, because it is capable in some measure of being filed and polished, especially after it has been exposed during several hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

Mr. Reaumur found, that by cementing cast iron with absorbent earths in a red-heat, the metal may be rendered softer, tougher, and consequently a fit material for many utensils formerly made of forged iron. Whether cementation with absorbent earths gives to cast iron a greater degree of these properties than the annealing commonly practised, has not been yet determined.

In Navarre, and in some of the southern parts of France, iron-ore is smelted in furnaces much smaller, and of a very different construction from those above described. A furnace of this kind consists of a wide-mouthed copper-caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The space or cavity contained by the masonry is the furnace in which the ore is smelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the cavity

name of soap, and the best chemists give it now to all combinations of any saline substances with oils, rendered miscible with water by means of these saline

cavity is about eight feet, and its smaller diameter is about six feet: the space of the furnace is gradually contracted towards the bottom, the greatest diameter of which does not exceed six feet: eighteen inches above the bottom is a cylindrical channel in one of the longer sides of the caldron and masonry, through which the nozzle of the bellows passes. This channel, and also the bellows-pipe, are so inclined, that the wind is directed towards the lowest point of the opposite side of the furnace. Another cylindrical channel is in one of the short sides of the furnace, at the height of a few inches from the bottom, which is generally kept closed, and is opened occasionally to give passage to the scoria; and above this is a third channel in the same side of the furnace, through which an iron instrument is occasionally introduced to stir the fluid metal, and to assist, as is said, the separation of the scoria from it. The greatest height of this channel is at its external aperture on the outside of the furnace, and its smaller height is at its internal aperture; so that the instrument may be directed towards the bottom of the furnace; but the second channel below it has a contrary inclination, that when an opening is made, the scoria may flow out of the furnace into a basin placed for its reception. When the furnace is heated sufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previously roasted. They take care to throw the charcoal chiefly on that side at which the wind enters, and the ore at the opposite side. At the end of about four hours a mass of iron is collected at the bottom of the furnace, which is generally about six hundred weight: the bellows are then stopp'd; and when the mass of iron is become solid, the workmen raise it from the bottom of the furnace, and place it, while yet hot, under a large hammer, where it is forged. The iron produced in these furnaces is of the best quality: the quantity is also very considerable, in proportion to the quantity of ore, and to the quantity of fuel employed. In these furnaces no lime stone or other substance is used to facilitate the fusion of the ore. We should receive much instruction concerning

the smelting of iron-ore, if we knew upon what part of the process or circumstance, the excellence of the iron obtained in these furnaces depends; whether on the quality of the ore; on the difuse of any kind of flux, by which the proportion of vitreous or earthy matter, intermix'd with the metallic particles, is diminished; on the forging while the iron is yet soft and hot, as the Marquis de Courtivron thinks; or on some other cause, not observed.

The iron thus produced by smelting ores is very far from being a pure metal; and though its fusibility renders it very useful for the formation of cannon, pots, and a great variety of utensils, yet it wants the strength, toughness, and malleability, which it is capable of receiving by further operations.

Cast-iron seems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cause of its fusibility, brittleness, hardness, and other properties by which it differs from forged iron. The sulphur, arsenic, and other impurities of the ores, which are sometimes contained in cast iron, are probably only accidental, and may be the causes of the red-short quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned seems principally to distinguish cast iron from forged or malleable iron; for, first, by depriving the former of this earthy matter, it is rendered malleable, as in the common process hereafter to be described; and, secondly, by fusing malleable iron with earthy and vitreous matters, it loses its malleability, and is restored to the state and properties of cast iron.

The earthy vitreous matter contained in cast iron consists probably of some of the ferruginous earth or calx of the ore not sufficiently metallized, and also of some unmetallic earth. Perhaps it is only a part of the scoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more separated, as the heat applied is more intense, and as the fusion is longer continued.

To separate these impurities from cast iron, and to unite the metallic parts more closely



substances. The vegetable kingdom contains many such saline, oily combinations soluble in water. All vegetable acids, fluor or concrete; essential salts; sac-

closely and compactly, and thus to give it the ductility and tenacity which render this metal more useful than any other, are the effects produced by the following operations.

The first of these operations is a fusion of the iron, by which much of its impurities is separated in form of scoria; and by the second operation, a further and more complete separation of these impurities, and also a closer compaction of the metallic particles, are effected by the application of mechanical force or pressure, by means of large hammers.

Some differences in the construction of the forge or furnace, in which the *fusion* or *refining of cast iron* is performed, in the method of conducting the operation, and in some other circumstances, are observed to occur in different places. We shall describe, from Suedenborgius, the *German method*.

The fusion of the cast-iron, which is to be rendered malleable, is performed upon the hearth of a forge similar to that used by blacksmiths: at one side of this hearth is formed a cavity or fire place, which is intended to contain the fuel and the iron to be melted: this fireplace is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep: it is bounded on three sides by three plates of cast-iron placed upright; and on the fourth side, which is the front, or that part nearest to which the workmen stand, by a large forge-hammer, through the eye of which the scoria is at certain times allowed to flow. The floor also of the fire-place is another cast-iron plate. The thickness of these plates is, from two to four inches. One of the upright side-plates rests against a wall, in an aperture thro' which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of case or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube rests upon the upper edge of the side-plate which leans against the wall, nearer to the back-part than to the front of the fire-place, and in such an oblique

direction, that the wind shall be impelled towards the furthest part of the floor of the fire-place, or where this floor is intersected by the opposite side plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be shifted till its proper position is found. The more nearly its direction approaches to a horizontal plane, the more intense is the heat; but a larger quantity of fuel is consumed than is even proportional to the encrease of heat, because the flame is not then so well confined. When the iron is easily fusible, great heat is not required: the tuyere may then decline considerably from the horizontal plane, and thus fuel may be saved. This tuyere, though made of copper, a metal more easily fusible than iron, is preserved from fusion by the constant passage of cold air through it. It must be carefully kept open, and cleansed from the scoria, which would be apt to block its cavity, by which not only the heat would be too much diminished for the success of the operation, but the tube itself would be melted.

To prepare for the fusion, a quantity of scoria of a former operation is thrown into the fire-place, till one-third part of it is full; and the remaining two-thirds of the fire-place are to be filled with smaller scoria, coal dust, and sparks ejected from hot iron. These matters, being fusible, form a bath for the reception of the iron when melted. Upon this bed of scoria, the mass of cast-iron to be melted is placed; so that one end of it shall be within the fire-place, opposite to the tuyere, and at the distance of about four or five inches from its aperture; and the other end shall stand without the fire-place, to be pushed in, as the former is melted. The upper side of the mass of iron ought to be in the same horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its course, strike upon and pass along the under-side of the mass: but if the iron be difficultly fusible, the tuyere is to be disposed more horizontally, so that the wind shall strike directly upon the mass of iron; and that one part of the blast shall graze along the upper surface, and the other part along the under surface of the iron.

charine juices; the extractive matter of plants, properly so called, are saponaceous substances, or acid soaps. In many of these soaps, such as essential

iron. The mass of iron weighs generally from two hundred to four hundred pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being more unfusible than the red-short. The iron being placed, charcoal-powder is thrown on both sides, and coals are accumulated above, so as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consumed, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added; but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entirely the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by

the cold air. At the same time also, they open a passage in the eye of the hammer placed in the front of the fire place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bellows are stopped, the coals are removed, and the mass is left during an hour; and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal powder and burnt ashes are thrown; but towards the tuyere, dry and entire pieces of coals are placed, to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it pass equally along the under surface of the iron, quite to the further extremity, and that it do not escape at the sides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted. When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and

salts and vegetable acids, the saline part predominates over the oily part, and they have therefore been considered rather as salts, than as soaps. But the oil

and put upon the ground of the forge, where it is cleaned from scoria, and beat into a more uniform shape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This mass is to be divided into five, six, or more pieces, by means of a wedge; and these are to be heated and forged till they are reduced to the form of the bars, commonly sold.

In some forges, the iron is fused only once, and in others it suffers three fusions, by which it is said to be rendered very pure. Where only one fusion is practised, it is called the *French method*. In this, no greater quantity of iron is fused at once than is sufficient to make one bar. The fireplace is of considerably less dimensions, and especially is less deep than in the German method above described. The fire is also more intense, and the proportion of fuel consumed to the iron is greater. The iron, when melted, is not kept in a state of ebullition as is above described; but this ebullition is prevented by stirring the fluid mass with an iron bar, till it is coagulated, and becomes solid.

By these operations, fusion and forging, the iron loses about  $\frac{1}{4}$  parts of its former weight, sometimes more and sometimes less, according to the quality of the cast iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more closely compacted, its texture is changed, and it is rendered more dense, soft, malleable, tough, and difficultly fusible.

The degrees however of these qualities vary much in different kinds of iron. Thus some iron is tough and malleable, both when it is hot and when it is cold. This is the best and most useful iron. It may be known generally by the equable surface of the forged bar, which is free from transverse fissures or cracks in the edges, and by a clear, white, small-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-short* iron, and is generally known by a texture consisting of large, shining plates, without any fibres. It is less liable to rust than other iron. A third kind of iron, called *red-short*, is brittle when hot, and malleable when cold. On

the surface and edges of the bars of this kind of iron, transverse cracks or fissures may be seen; and its internal color is dull and dark. It is very liable to rust. Lastly, some iron is brittle both when hot and when cold.

Most authors, agree that the red-short quality of iron proceeds from some sulphur or vitriolic acid being contained it, because sulphur is known to produce this effect when added to iron; and because the iron obtained from pyritous and other sulphurated ores has generally this quality.

The cause of the cold-short quality of iron is not so well ascertained. Some imagine that it proceeds from a mixture of arsenic or of antimony. But this opinion seems to be improbable, when we consider that these metallic substances may in a great measure be dissipated by roasting, whereas the ores which yield a cold-short iron are injured by much roasting; that no arsenic or antimony are observable in most, if in any, of these ores; and lastly, that these semi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be destroyed by cementation with phlogiston, and by forging. And lastly, others ascribe the cold-short quality of iron to a defect of phlogiston, or, as Suedenborgius says, of sulphur. To ascertain the causes of the bad qualities of iron, and to discover practicable remedies, are still desiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be observed, which run all along its whole length: and scarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the smelting; and also from that practice of mixing two or more pigs of cast iron of different qualities in the finery of these: by which means, the red-short and the cold-short qualities of the different kinds are not, as we have already remarked, mutually counteracted or destroyed by each other, but each of these qualities is diminished in the mixed mass of iron, as much as this

contained in all these compounds is rendered perfectly miscible with water by means of the saline matter, and it is consequently in a state truly saponaceous.

this mass is larger than the part of the mass originally possessed of that quality: That is, if equal parts of red-short and of cold-short iron be mixed together; the mixed mass will be only half as red-short as the former part, and half as cold-short as the latter. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other, but not of being intimately united or combined.

### *Of the SMELTING of TIN-ORES.*

The tin-ores commonly smelted are those which consist of calx of tin combined with calx of arsenic and sometimes with calx of iron. These are either pure, as the tin-graies, or intermixed with spars, stones, pyrites, ores of copper, iron, or of other metals.

The impure ores must be *cleaned* as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of tin than of any other metal, because in the smelting of tin-ores a less intense heat must be given than is sufficient for the scorification of earthy matters, lest the tin be calcined. Tin-ores previously bruised may be cleaned by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones or ferruginous ores, a slight roasting will render these impure matters more friable, and consequently fitter to be separated from the tin-ores. Sometimes these operations, the roasting, con-tusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleaned from adhering heterogeneous matters, is to be *roasted* in an oven or reverberatory furnace with a fire rather intense than long continued, during which it must be frequently stirred to prevent its fusion. By this operation, the arsenic is expelled, and in some works is collected in chambers built purposely above the calcining furnace.

Lastly, the ore cleaned and roasted is to be *fused*, and reduced to a metallic state. In this fusion, attention must be given to the following particulars. 1. No more heat is to be applied than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is used in this than in most other fusions. 3. The scoria must be frequently removed, lest some of the tin should be involved in it, and the melted metal must be covered with charcoal powder to prevent the calcination of its surface. 4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

### *SMELTING of ORES of LEAD.*

Ores of lead are either *pure*, that is, containing no mixture of other metal; or they are *mixed* with silver, copper, or pyrites. The methods of treating ores of lead containing silver and copper, are described in the articles *SMELTING of ORES of SILVER* and of *COPPER*; and in the former of these articles, an instance is given of the method of smelting the ore of Rammelsberg, which contains all these three metals.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expence of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead is obtained by a kind of *eliquation*, during the roasting of the ore. For this purpose, the ore is thrown upon several strata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a basin placed for its reception. The ore which is thus roasted is beat into smaller pieces, and exp-<sup>ed</sup> to a second operation similar to the former, by which more metal

We may also combine acids directly with oils, and thus may form artificially acid soaps. But these operations are difficult and exhibit many singular appearances,

metal is eliquated; and the remaining ore is afterwards ground, washed, and smelted in the ordinary method.

The lead of Willach is the purest of any known. Schlutter ascribes its great purity to the method used in extracting it, by which the most fusible, and consequently the purest part of the contained lead is separated from any less fusible metal which happens to be mixed with it, and which remains in the roasted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are smelted either upon a hearth, or in a reverberatory furnace, called a *cupol*.

In the first of these methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fusion is very quickly effected; and the lead flows from the hearth as fast as it is separated from the ore.

3. In the second method practised in England, pit-coal is used as fuel. The furnace is represented by Fig. 14. and 15. PLATE II. The ore is melted by means of the flame passing over its surface; its sulphur is burnt and dissipated, while the metal is separated from the scoria, and collected at the bottom of the furnace. When the ore is well cleansed and pure, no addition is requisite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fusible spar found in the mines is generally added to render the scoria more fluid, and thereby to assist the precipitation of the metal. When the fusion has been continued about eight hours, a passage in the side of the furnace is opened, through which the liquid lead flows into an iron cistern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid mass a quantity of slaked quicklime, which renders the scoria so thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the smelting of lead-ores in England, but thinks that it is intended to facilitate the fusion of the ore, whereas it really has a contrary effect, and is never added till near the end of the opera-

tion, when the scoria is to be raked from the surface of the metal.

### *Of the SMELTING of ORES of SEMI-METALS.*

ANTIMONY is obtained by a kind of eliquation from the minerals containing it, as is described in the article ANTIMONY; and the regulus of antimony is procured from antimony, by the processes described in the same article, and in the article REGULUS of ANTIMONY.

ARSENIC, SAFFRE, and BISMUTH are obtained generally from one ore, namely, that called *cobalt*. The arsenic of the ore is separated by roasting, and adheres to the internal surface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the sides of which are several doors, by means of which the arsenic, when the operation is finished, may be swept out and collected. These chimneys are generally bent, in a zig-zag direction, that they may better retard and stop the arsenical fumes. These flowers are of various colors, white, grey, red, yellow, according to the quantity of sulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated sublimations; while some alkaline or other substances are added to detain the sulphur, and to assist the purification.

In the same roasting of the ore by which the arsenic is expelled, the bismuth, or at least the greatest part of this semimetal which is contained in the ore, being very fusible, and having no disposition to unite with the regulus of cobalt, which remains in the ore, is separated by eliquation.

The remaining part of the roasted ore consists chiefly of calx of regulus of cobalt, which not being volatile, as the arsenic is, nor so easily fusible as bismuth is, has been neither volatilized nor melted. It contains also some bismuth, and a small quantity of arsenic, together with any silver or other fixed metal which happened to be contained in the ore. This roasted ore being reduced to a fine powder, and mixed with three or four times its weight of fine sand, is the powder

according to the state and nature of the acids and oils combined. Vitriolic and nitrous acids, especially when well concentrated, act so powerfully upon all drying, sweet, or essential oils, that they produce considerable alterations. Nitrous acid inflames them, or, when not sufficiently concentrated to produce this inflammation, it reduces them, as the vitriolic acid also does, into thick, resinous, and bituminous compounds. The action of these acids appears less strong upon the fat oils, which do not dry, and are capable of forming with them true acid soaps. But all these matters have been but superficially examined, and may be considered, by persons desirous of extending chemical knowledge, as a new subject.

DCXXXIV. S O A P (C O M M O N). Common soap is a combination of oil of olives with fixed alkali rendered caustic by quicklime. Soap may be made by several methods, which however all depend upon the

powder called *saffre* or *zaffre*. See SAFFRE. Or the roasted ore is sometimes fused with about thrice its quantity of pure sand and as much pure potash, by which a blue glass, called *smalt*, is produced (see SMALT), and a metallic mass, called *speiss*, is collected at the bottom of the vessel in which the matters are fused. The metallic mass or speiss is composed of very different substances, according to the contents of the ore and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, bismuth, arsenic, sulphur, copper, and silver.

Bismuth is seldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a sufficient quantity of these was found, by the same method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and enveloped in much earthy or other matter, from which it cannot be separated merely by washing, is distilled either by ascent, or by descent. When it is mineralised by sulphur, that is, when it is contained in cinnabar, some intermediate substance, as quicklime, or iron, must be added in the distillation, to disengage it from the sulphur. See CINNABAR.

The rich ore of Almaden in Spain is a cinnabar, with which a calcareous stone happens to be so blended, that no addition is required to disengage the mercury from the sulphur. The distillation is there performed in a furnace consisting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, resting upon a grate, through the bars of which the air enters, maintains the fire, and passes into a chim-

ney, placed at one side of the fire-place immediately above the door through which fuel is to be introduced. The roof of this fire place, which is vaulted and pierced with several holes, is also the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be distilled is introduced, through a door in one of the sides of the furnace. In the opposite wall of this cavity are eight openings, all at the same height. To each of these openings is adapted a file of aludels connected and luted together, extending sixty feet in length. These aludels, which are earthen vessels open at each end, and wider in the middle than at either extremity, (see ALUDEL and PLATE I.) are supported upon an inclined terras; and the aludel of each file, that is most distant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled sufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatilised, and its vapor passes into the aludels, where much of it is condensed, and the rest is discharged into the brick-chamber, in which it circulates till it also is condensed. If any air or smoke passes through the aludels along with the vapor of the mercury, they escape through the two chimneys of the chamber. Three days after the operation, when the apparatus is sufficiently cooled, the aludels are unluted, and the doors of the chamber are opened, and the mercury is collected.

same

same principle. The soap which is used in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spanish soda are boiled together, during a short time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phiol which is capable of containing an ounce of water, shall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of sweet almonds, in a glass or stone-ware vessel. The mixture is to be stirred from time to time with an iron spatula, or with a pestle, and it soon becomes thick and white. The combination is gradually completed, and in seven or eight days a very white and firm soap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and soda is made, but is less concentrated than that above described, and only so much that it can sustain a fresh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the rest of the lixivium is to be added to it, and the whole is to be digested with a very gentle heat, till the soap be completely made. A trial is to be made of it to examine whether the just proportion of oil and alkali has been observed. Good soap of this kind ought to be firm and very white when cold, not subject to become moist by exposure to air, and entirely miscible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the surface. When the soap has not these qualities, the combination has not been well made, or the quantity of salt or of oil is too great, which faults must be corrected.

In soft or liquid soaps, green or black soaps, cheaper oils are employed, as oil of nuts, of hemp, of fish, &c. These soaps, excepting in consistence, are not essentially different from white soap.

Any fixed alkalis are much disposed to unite with oils that are not volatile, both vegetable and animal, since this union can be made even without heat. The compound resulting from this union partakes at the same time of the properties of oil, and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap is less combustible than when pure, from its union with the alkali, which is an unflammable body. It is miscible or even soluble in water to a certain degree, by means of the alkali. Soap is entirely soluble in spirit of wine, and still better in aqua vitæ sharpened by a little alkaline salt, according to an observation of Mr. Geoffroy.

When oil unites with alkali in the formation of soap, it is little altered in the connexion of its principles, for it may be separated from the alkali by decomposing soap with any acid, and may be obtained nearly in its original state. By the accurate investigation that Mr. Geoffroy has made of soap, by decomposing it thus by means of an acid, he found that two ounces of this compound consist of one ounce, three gros and one scruple of oil, one gros and a scruple

marine alkali deprived of all oil and moisture, or twice the quantity of this salt containing the water of its crystallization, and, lastly, two gros and four grains of water. This latter quantity of water is nevertheless variable, according to the condition of the soap; for it may be much more or much less dry.

Concerning the decomposition of soap by means of acids we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting a fixed alkali, or the inflammable principle, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with basis of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acid of these salts, may unite more or less intimately with the substance which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has done. When first exposed to fire, it yields a phlegm called by him a spirit; which nevertheless is neither acid nor alkaline, but some water which enters into the composition of soap. It becomes more and more colored and empyreumatic as the fire is increased, which shews that it contains the most subtle part of the oil. It seems even to raise along with it, by help of the oil and action of the fire, a small part of the alkali of the soap: for, as the same chemist observes, it occasions a precipitate in a solution of corrosive sublimate. After this phlegm, the oil rises altered, precisely as if it had been distilled from quicklime, that is, empyreumatic, soluble in spirit of wine, at first sufficiently subtle and afterwards thicker. An alkaline residuous coal remains in the retort, consisting chiefly of the mineral alkali contained in the soap, and which may be disengaged from the coal by calcination in an open fire, and obtained in its pure state.

As all oils contain an acid more or less combined, which may also be more or less disengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the soap is saturated with the acid of the oil, especially after the distillation of the soap. But this matter has not been so well examined, that we can affirm any thing concerning it.

Alkaline soaps are very useful in many arts and trades, and also in chemistry and medicine. Their principal utility consists in a deterfive quality that they receive from their alkali, which, although it is in some measure saturated with oil, is yet capable of acting upon oily matters, and of rendering them saponaceous and miscible with water. Hence soap is very useful to cleanse any substances from all fat matters with which they happen to be soiled. Soap is therefore daily used for the washing and whitening of linen, for the cleansing of woollen-cloths from oil, and for whitening silk and freeing it from the resinous varnish with which it is naturally covered. Pure alkaline lixiviums being capable of dissolving oils more effectually than soap, might be employed for the same purposes; but when this activity is not mitigated by oil as it is in soap, they are capable of altering and even of destroying entirely by their causticity most substances, especially animal matters, as silk, wool, and others: whereas soap cleanses



cleanses from oil almost as effectually as pure alkali, without danger of altering or destroying, which renders it very useful.

Soap furnishes medicine with a very efficacious and valuable remedy. Till lately, that Mrs. Stephen's lithontriptic remedy has been published, physicians attended little to the medicinal qualities of soap. They soon found that soap, which is the principal ingredient of this famous remedy, is also the only one which has any real efficacy. And although this remedy has been found to be insufficient to dissolve most stones of the bladder, yet experience and observation have sufficiently evinced that it can prevent the enlargement, or even the formation, of stones in persons disposed to that disease; that it can, in a word, attenuate, divide, and expel the stoney particles generated in the urinary passages, and which are the first materials of the stone. And accordingly soap is frequently used successfully in these cases. When soap was once discovered to act sensibly on the glue or binding substance of that urinary sand, gravel, and even of some stones, it was naturally supposed to be capable of acting more powerfully on other thickened matters, which are too frequent causes of many obdurate diseases. These considerations have induced the best practitioners to prescribe soap as a resolving, aperitive, and deobstruent remedy; and we are certain that it has been employed as such with great success.

From the properties of soap we may know that it must be a very effectual and convenient anti-acid. It absorbs acids as powerfully as pure alkalis and absorbent earths, without having the causticity of the former, and without oppressing the stomach by its weight, like the latter.

Lastly, we may perceive that soap must be one of the best of all antidotes to stop quickly, and with the least inconvenience, the bad effects of acid corrosive poisons, as aqua fortis, corrosive sublimate, &c.

DCXXXV. S O A P. (S T A R K E Y's). This preparation is a combination of fixed vegetable alkali with essential oil of turpentine. It is named from the inventor, a chemist, called Starkey, who endeavoring to resolve the problem of the volatilisation of salt of tartar, combined that alkali with several substances; and particularly with oil of turpentine, and remarked that from this latter mixture a saponaceous compound was formed, which has been supposed to possess many medicinal virtues. It enters into the composition of pills, named also from Starkey. The belief of its good qualities has induced persons to continue the preparation of this soap, and to endeavor, but without success, to improve the process.

Although fixed alkalis are not absolutely inactive upon essential oils, they cannot however unite as easily with these, as with sweet oils, which are not volatile. If we attempt to combine any essential oil, and particularly oil of turpentine, with liquid fixed alkali, as in the preparation of ordinary soap, we shall soon find that these two substances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his soap than time and patience. His method, which is perhaps the best of all, consists in putting dry alkali into a matras, and pouring upon it essential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was completed. In five or six months a part of the alkali and oil are thus combined together, and form a sort of white saponaceous compound. This soap

must be separated from the mixture, and more of it will be afterwards formed in the same manner.

Shorter methods have been searched for the preparation of this soap, by several chemists; and amongst these is the illustrious Stahl, who considering water as part of the combination of every soap, and even that it is a medium by which the salt and oil are united together, directs that after having mixed oil of turpentine with very hot alkali, and having shook them together, this mixture should be exposed in a moist place, that all the portion of alkali which does not unite with the oil may deliquiate, and be separated from the part of the mixture that is combined; that this alkali should then be dried, and new oil poured upon it, as at first; and, lastly, that this method should be continued till the whole be reduced into soap; and thus the operation will, as he affirms, be greatly shortened. Nevertheless, later chemists, not satisfied with this method of Stahl, have endeavoured to simplify still more this operation. Mr. Rouelle the younger has published in the *Journal de Medicine*, that he has discovered a more expeditious method than all those hitherto known for the preparation of this soap. Mr. Beaumé has also published in the *Gazette de Medicine* a method of making it in a few hours. It consists in triturating, during a long time, alkaline salt upon a porphyry, and in adding to this salt, during the trituration, oil of turpentine. According to this able chemist, the thick resinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is dissipated. For which reason, according to him, a very great quantity of oil of turpentine is requisite for the formation of Starkey's soap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and also the trituration upon the porphyry, by promoting the evaporation of the subtle part of the oil, accelerates considerably the operation of Starkey's soap.

Another artist says, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this soap ready made; which corresponds with Mr. Beaumé's opinion. Lastly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary soap, considerably abridges the operation; and this also confirms his opinion, which seems to be very probable. We do not mean to blame the zeal of these chemists in making so many attempts to find a method of preparing this soap quickly, but we confess that the importance of the object does not seem adequate to their trouble. For, in fact, what does it signify whether this soap, not used in the arts, and but little in medicine, be quickly or slowly made? The essential point is not that it be quickly, but well done.

And to speak our sentiments freely, this preparation seems to be uncertain and ill-chosen. For, besides that the true soap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the usual idea of it, is a thing probably impossible, we believe that we may affirm, that the saponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the same state, and by time necessarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only these soaps made by different processes, but also the same soap, a longer or a shorter  
time

time after it has been made, and we shall find considerable differences in their color, smell, and consistence. We shall find that those deliquiate, and are partly resolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of saturating well the fixed alkali; that others acquire by time a pitchy, yellowish, semi-transparent and resinous appearance, which contain too large a quantity of thick residuum of oil of turpentine. Those soaps which seem to be the best made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preserve longer their white color and the consistence of true soap: But they nevertheless participate more or less of the faults we have mentioned. Lastly, all these soaps are liable to contain a considerable quantity of a sort of neutral salt, formed by the acid of the oil of turpentine, united with a part of the alkali of the soap. This salt crystallizes upon the surface, and even within the soap, which in time becomes quite penetrated and stuck all over with a saline efflorescence. These bad qualities and alterations of Starkey's soap cannot be avoided by any method, as they depend on the nature of essential oils, which we cannot change. These soaps are known to contain a volatile and superficially combined acid, which unfolds itself more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker consistence. We are no less certain that the most ethereal part of essential oils, or their spiritus rector, is so volatile, that however attentive we may be to preserve it, it will gradually dissipate in time: in a word, we know from experience, that all essential oils are drying, and are much more spontaneously alterable than any others; and that these spontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by absorbing their acid, and by facilitating the dissipation of their ethereal part, with which the alkali is not capable of forming a true union, can only hasten the alterations to which the oil is naturally disposed.

From all this we ought to conclude, that Starkey's soap is a difficult, uncertain, variable preparation, which is continually changing its nature, and consequently its medicinal virtues. This latter inconvenience, although it were the only one, would be sufficient to make us reject this preparation. And therefore, if, as is probable, a saponaceous substance, partaking of the properties of fixed alkali and of an essential oil, would be useful in medicine, ordinary soap, incorporated extemporaneously with any quantity of essential oil which shall be judged proper, might be substituted instead of Starkey's soap.

See OILS (ESSENTIAL).

DCXXXVI. S O A P - R O C K, or SOAP-STONE. See STEATITES.

DCXXXVII. S O D A. (r)

DCXXXVIII. S O L U T I O N. Solution consists in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the result of this union, we hence see that solution is nothing else than the act of combination.

As the integrant parts of one body cannot unite with those of another, while

(r) Soda is a name given to the maritime plant *kali*, from the ashes of which a considerable quantity of mineral alkali may be obtained; and also to the ashes themselves, or to an impure alkaline salt extracted from these. See KALI, and ALKALI (MINERAL). they

they adhere together; therefore solution cannot be made till the aggregation of one of the two bodies at least is broken. And as bodies whose aggregation is broken are necessarily in a state of fluidity or of vapors, an axiom has been formed, *Corpora non agunt nisi sint fluida*, or, Bodies do not act unless they be fluid.

The two bodies which unite in solution are usually distinguished by two different names. That body is generally called the *solvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taste or from its solidity appears to be altogether passive, is said to be *dissolved*. Thus, for example, when metal or marble is dissolved in aqua fortis, these solid bodies are considered as being *dissolved*, and aqua fortis as the *solvent*. But these expressions ought not to be taken literally, for they would give a very false idea of what really happens in solution. On the contrary, we are certain that any two bodies, which unite together in solution, reciprocally exercise their action one upon another, and that the union which results from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this respect, that body, whose specific gravity is greatest, acts most strongly. Mr. Gellert, considering the thing in this point of view, affects to represent as *solvents* the bodies which are generally considered as *dissolved*, and says, for instance, that *sand dissolves alkali*. Provided that we understand that the action of the combining bodies is mutual, it signifies little that we name the one *solvent*, and the other the body *dissolved*: and even as the word *solution*, taken in its most proper signification, expresses the separation of the integrant parts of a body, we seem to speak more clearly and accurately when we call that body the *solvent*, whose integrant parts are already separated before the solution, and that the *body dissolved* whose integrant parts are only disunited during the act of solution.

As the solution cannot be effected unless one of the two bodies at least be fluid, and as solid bodies only become fluid by the interposition of the parts of some other fluid, such as water and watery liquors, or fire, hence solution may be made either by the *humid* or by the *dry way*. The solutions in which the integrant parts of one of the two bodies, or of both, are distributed in an aqueous fluid, as, for instance, those of acids, are *solutions by the humid way*; and those solutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in alloys of metals with each other, are *solutions in the dry way*.

The solution of bodies is not perfect, unless each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be transparent, we ought to have, after the mutual solution, a transparent compound, as happens in the solutions of calcareous stones and acids, and of those of earths by alkalis. As therefore the solution of soap in water is always a little opaque and milky, it ought not to be considered as complete. The same may be said of glasses that are not perfectly transparent. Their want of transparency always proceeds from the parts of the sand or flint not having been sufficiently dissolved by the salt, or from their containing some refractory

refractory matters, such as certain metallic calxes, particularly calx of tin, which resist the action of salts.

As the solution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the solution, these parts are found to adhere together: hence also heavy bodies may be suspended in the thinnest and lightest liquids, when they are truly dissolved by each other. For instance, corrosive sublimate, which is very heavy, may be suspended by spirit of wine, which keeps it dissolved, altho' this liquor be very light. See COMPOSITION and COMBINATION.

DCXXXIX. S O O I'. Soot is a collection of substances formed by the matter of the flame of inflammable bodies, but which have escaped combustion, from not having sufficient contact with the air. This matter, which fixes itself to the internal surface of chimneys, is always of a black color, more or less brownish. This color it receives from an oil that is burnt, and half reduced to the state of coal.

As all inflammable bodies undergo a total decomposition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of those which are volatile, are raised in vapors, some part of which burns with flame, is totally dissipated and destroyed, and another part is sublimed and adheres to the first cold bodies which it meets.

Soot is, as we have now observed, the portion of flame which is reduced to black smoke, and which has not been inflamed from want of sufficient contact with air. For if the vapors exhaling from an inflammable body strongly heated were so rarefied that each of their parts should be altogether surrounded by air, they would all burn with flame, and then we should have no smoke or soot, or at least this soot would not be black, and would contain nothing inflammable. For which reason, the greater quantity of air is admitted amongst bodies which burn with flame, the less smoke and soot we have; and also, the soot proceeding even from bodies of the same kind must be very different according to the manner in which they are burnt. In general, we can say nothing that will be constantly applicable to the nature and principles of soot, as its differences arise not only from the causes above-mentioned, but also from the nature of the inflammable substances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, must furnish a soot different from that of animal matters; and the soot of a pure oil must be different from that of a plant containing all its principles. But these differences have not yet been observed, because chemists have not attended to this subject.

We know only that the ordinary soot of chimneys has an acrid, bitter, empyreumatic, and disagreeable taste; that water can extract from it a dusky-colored matter, which shews that it contains saline, oily, saponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are set on fire.

If this soot be distilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid also may possibly be obtainable from certain soots.

and generally towards the end of the distillation, when the heat is strong, a little sal ammoniac is sublimed.

As every foot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables suffer, by combustion in an open fire, changes similar to those occasioned by putrefaction. Besides, the quantity of fixed coal which remains after the distillation of foot, and which furnishes a fixed alkali, together with much earth, by incineration, shows that a very considerable quantity of the fixed principles of inflammable bodies is carried off, and even raised to a great height, by means of their combustion with flame: but, as we have said, foots are very different; and the matter is but little known, and requires further researches.

DCXL. S O R R E L. (s)

DCXLI. S P A R. Naturalists and chemists have given this name to certain crystallized stones, more or less transparent, which generally do not strike fire with steel, and which are found plentifully within the earth, but more especially in mines of metals.

Under this general name many stones are comprehended; because they have the general properties we have mentioned, and because they resemble each other by the form of their crystallization, in which we always perceive shining plates, like mirrors; but some of these stones are very different from others.

Some spars are entirely soluble with effervescence in acids, forming selenites with vitriolic acid, deliquescent salts with nitrous and marine acids, and convertible into quicklime by calcination. These stones are justly called *calcareous spars*.

Others, although entirely similar to these in appearance, do not effervesce with acids, are calcinable as gypsum and selenites are, and are, in fact, true selenites composed of vitriolic acid and calcareous earths. These spars are essentially different from the former, and are *gypsous* or *selenitic spars*.

Other spars are neither calcareous nor selenitic, do not lose their transparency in the fire, and seem to be of the nature of *talc*.

Lastly, a kind of stone, crystallized in mirror-like plates like a true spar, is almost opaque, is indissoluble by acids, and is so much harder than all other spars as to be capable of striking fire with steel. This stone is fusible without addition, by the action of a violent fire, into a semi-transparent white matter. This seems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fusible spars*. They also mention another spar which is compact, breaks like glass, and melts without addition. From the descriptions given by most authors we cannot easily discover what they mean by fusible spar, and by *quartz-spar*. These matters have not yet been sufficiently examined.

From the properties of all the substances called spars we may conjecture, that they are stones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of some metallic

(s) SORREL. The leaves of this plant contain an acid salt which may be obtained from the expressed juice by crystallisation. From twenty pounds of fresh sorrel-leaves Neuman expressed six pounds of juice, from which two ounces, two drams and one scruple of crystallised salt, together with two ounces and six drams of an impure saline mass, were obtained. See SALT (ESSENTIAL) of SORREL.

earths,

earth, or even by a metallisation begun in their own earth, some properties common to all, or, at least, to the greatest number.

These properties are, 1. A certain form of shining laminæ in their crystallization, which appears even in those, the figure of whose crystals seems least disposed to receive this form, as in those which are striated; for sparry laminæ are distinguishable at the extremities of the striæ, or bundles of striæ, of which these spars are composed.

2. A greater specific gravity than of all other stones. Some spars, especially those called *heavy spar*, are so very heavy, that they come near in this respect to metals.

3. A greater fusibility than of other stones; for, besides those spars which are fusible without addition, the mixture of spars facilitates the fusion of most other earths and stones, and they are accordingly used as fluxes in the smelting of most metallic ores. Probably for this reason these stones have been called *flux* by many mineralogists and metallurgists.

Lastly, many spars are found colored by metallic principles, and imitate the colors of the several precious stones, although they are less beautiful and vivid.

We shall not enter into a more particular detail concerning spars, because what is further known about them rather belongs to natural history than to chemistry; besides that our knowledge of spars is very indistinct. (1)

(1) **SPARS.** This name is given to many stones of different properties and appearances, which do not possess constantly any one common character or mark by which they may be certainly distinguished from other stones. In general, we may observe, that they are most frequently found in mines, and that they generally consist of smooth and shining plates or laminæ; that some are transparent, and others opaque; that some are colorless, and others are colored; that they are crystallized in various determinate figures, or possess no determinate shape; and, lastly, that they differ so much in hardness, density, degree of fusibility, and in their most essential chemical properties, that they cannot be considered as forming a distinct class or fossil substance. We need not wonder, therefore, that authors, especially those who have not been much concerned in the examination of fossil bodies, should have given very confused and differing descriptions of spars. Many of them have not been sufficiently examined; but those, at least, who have acquired some knowledge, will still endeavor to distinguish among them several different kinds, and to distinguish them, so far as is done in the present state of science.

The spars, however, which the name of *spars* has been given to, are, the *calcareous*, the *gypsum*, the *heavy spar*, and the *fluor*.

1. *Calcareous spars* are soft, heavy stones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called *rhomboidal*. Some spars, called *dog's tooth-spar*, have a pyramidal figure; but when these are broken, their fragments show that they also consist of rhomboidal particles.

Some rhomboidal spars are transparent, others are opaque; some are colorless, and others are colored; lastly, some of them have a singular property of refracting doubly the rays of light which pass through them, and thereby of representing any object, as, for instance, the letters of a book, seen through it, double. This spar has been called *double crystal*, or *refracting spar*. Its figure is that of an oblique parallelogram, contained within six parallelogram sides and eight solid angles. Each of the obtuse angles of the parallelogram is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. These are the dimensions given by Sir Isaac Newton of the angles of the sides of the refracting spar; and I have found them to correspond exactly with those which I have seen.

Calcareous spars may be distinguished from others by effervescing with acids.

2. *Gypsum* or *plaster spar*. These are gypcious

DCXLII. **S P E L T E R.** Zinc is sometimes so called. See **ZINC.**

DCXLIII. **S P E R M A - C E T I.** (u)

DCXLIV. **S P I R I T.** The name of spirit is given in general to all liquors obtained from substances by distillation. Spirits are of three principal kinds, namely, *inflammable spirits*, *acid spirits*, and *alkaline spirits*.

The class of inflammable spirits includes the most volatile and thinnest part of essential oils; the principle of smell, or the *spiritus rectus* of plants; and *ardent spirits*, or the spirit obtained from wine, beer, and all liquors which have undergone the *spirituous fermentation*.

In the second class are all acids obtained by distillation of minerals, vegetables, and of animals. Such are, 1. the acids of sulphur, vitriol, alum, all which are the same acid, namely, the vitriolic, and the acids of nitre and of common salt. They are called *spirit of sulphur*, *spirit of vitriol*, *spirit of nitre* &c. without specifying that they are acids. 2. The acids of *vinegar*, and of all liquors which have undergone the *acetous fermentation*, and the acids obtained in the distillation of vegetables, and of certain animals, as flies, ants, &c. These spirits are commonly called *acid spirits*, as the *acid spirit of guaiacum*, the *acid spirits of ants*, &c. because the substances which furnish them yield alkalis that are not acid.

gypseous earth, distinctly crystallized. The form of the crystals is rhomboidal. They are also called *selenites* and *glacies Mariae*. Sometimes these spars assume other forms. They are very heavy. See **SELENITES**, and **GLACIES MARIE**.

3. *Fusible spars*, called also *fluors*. Under this name many stones are comprehended of different shapes, appearances, and perhaps properties. Their general properties are described under the article **FLUOR**. They are most frequently found in mines, and are much used to facilitate the fusion of ores. Several fluors acquire a phosphoric property by calcination with inflammable matters. Such is the *Bolognian stone*; and also other white, heavy, friable, fusible spars, as Mr. Margraaf found. This chemist discovered, by analysing the Bolognian stone, and other fusible spars capable of receiving a phosphoric quality, that they consist of a gypseous earth united with a small quantity of clay. He also found, that several fusible spars could not receive the phosphoric quality of the Bolognian stone. What the cause of this difference is, and whether they all consist of the same constituent parts as those analysed by Mr. Margraaf, has not yet been discovered. See **FLUOR**.

4. *Fish-spar*, *Spatum scintillans*. This stone differs from all the foregoing, in being so

hard as to be capable of striking ignited sparks from steel. For which reason it is referred by Cronstedt to the siliceous class of earths, and is by him called *rhombic quartz*, because the particles of which it consists seem to be parallelepipeds, each of which is contained within six rhombic or rhomboidal sides. Its colors are various, white, grey, and red.

Several other fossil substances consist of large plates, and are therefore said to have a *sherry texture*. Such are some kinds of talk, of horn-blend, of quartz, of amianthus, and some calciform ores of metals.

(u) **S P E R M A - C E T I** is a white, flaky, unctuous substance, obtained from the heads of whales. It is altogether soluble in oils; but is not capable of being dissolved by caustic alkalis, and of forming soaps, as other oily matters may. By distillation it may be entirely rectified, without leaving any residuum. From four ounces of spermaceti three ounces and a half of oil, and a drachm and a half of residuum, were distilled. The oil distilled is not black, stinky, and empyreumatic, like that of other animal substances, but clear, yellowish, and of the consistence of butter. It does not render spermaceti perfectly miscible with water; but this may be better done by means of yolks of eggs. *Newman*.

Lastly,



Lastly, in the third class are liquid volatile alkalis, obtained from sal ammoniac, from all vegetable matters which have undergone a complete putrefaction, and from all animal matters. They are generally called *spirits*, only, without specifying their alkaline quality. Thus we say, *volatile spirit of sal ammoniac*, *spirit of hartshorn*, &c. As some of these substances, particularly sal ammoniac, contain also an acid which may be obtained from them, we ought, when we mention this spirit, to specify its acid quality, and to name it, for instance, *acid spirit of sal ammoniac*.

**DCXLV. SPIRIT (ARDENT).** Ardent spirit, called also *spirit of wine*, because it can be only obtained from substances which have undergone the vinous fermentation, is a very light, very volatile, very fluid liquor, perfectly white and limpid, and of a strong, penetrating, agreeable taste and smell.

This spirit may be easily inflamed, without being previously heated. Its flame is light, white in the center, blue at its edges, and not very luminous. It is not accompanied with any smoke or soot. It burns without noise, and without any suffocating or other vapors.

Spirit of wine perfectly pure, for of that I speak, burns also entirely, with concurrence of free air, without leaving the least vestige of coal, or of any saline, earthy, or other residuum.

Although spirit of wine be altogether inflammable, it is nevertheless miscible with water without any intermediate substance, and in all proportions, which is a specific character of this liquor; for it is the only substance of the kind known which is possessed of these properties.

If spirit of wine be exposed to heat in close vessels, it does not inflame, but is easily reduced into vapors which pass in distillation. These vapors, when collected, are entirely the same spirit of wine as before distillation, without having received any alteration or decomposition, however frequently the operation may have been repeated.

Juncker says, that if spirit of wine be burnt in a tubulated retort, to which a large glass receiver has been adapted, it will be changed into a very subtle vapor, which condenses in the receiver, and forms a liquor similar to pure water.

Boerhaave affirms, that when the vapor of burning spirit of wine is collected by an apparatus of proper vessels, it is nothing but very pure water.

The following are the principal properties of spirit of wine relatively to other substances.

It seems to have no sensible action upon earths, or upon metallic matters, nor even upon many neutral salts; but with acids, alkalis, and many oily substances it exhibits remarkable phenomena.

Spirit of wine unites with all acids; and by this union the acidity of these is diminished. Accordingly, the acids thus combined with spirit of wine, are called *acidified acids*. See *WATER OF RABEL'S SPIRIT OF NITRE*, and *SPIRIT OF SALT* (DELUCE).

But when it is mixed in certain proportions with concentrated acids, and distilled, at least with most of them, it then recovers from them, and produces upon them the following alterations.

First of all, some of it passes over dephlegmated as much as it can be without being essentially altered; afterwards it loses part of the water essential to it; consequently the nature of the remaining part is changed, and it is converted into a liquor, the properties of which show that it is almost approximated to the nature of oil as it is removed from that of spirit of wine. This liquor, which is very fluid and very volatile, is called *æther*, which is, according to what we have said, a substance exactly intermediate between alcohol spirit and oil. *See ETHER.*

After this, the spirit of wine, or its mixture with acids, assumes all the characters of oil, or rather becomes a genuine oil.

Acids, on their side, receive from spirit of wine, especially after the formation of ether, all the alterations which they usually receive from oils with which they have been treated and distilled. *See ETHER.*

Very strong and dephlegmated alkalis act singularly upon spirit of wine, and are even capable of decomposing it, when assisted by a certain degree of heat. They deprive it, first, of all its superabundant water, then of the water it contains as a principle, and, lastly, they reduce it to the condition of a true oil, without making it pass, as acids do, through the intermediate state of ether. *See TINCTURE of SALT of TARTAR.*

Spirit of wine is commonly considered as the solvent of oils and of oily matters; but properly it is the solvent only of one kind of oils. These are the essential oils and their concretions, such as balsams and resins; all which spirit of wine can dissolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain substances which seem to partake more of the nature of true resins, as copal and bitumens. *See OILS and RESINS.*

When spirit of wine keeps an oily matter dissolved, it may be separated by distillation, if the oily matter be not volatile, or by diluting the solution with a large quantity of water. This water, with which the spirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil dissolved. Hence the oily matter separates at first in very small globules, which are dispersed through the liquor, and give it the white appearance of an emulsion; and these globules afterwards collect, forming more considerable masses, by which the liquor is rendered very clear.

These properties of spirit of wine are advantageously applied to extract the essential oils and resins of vegetable matters.

Accordingly, by digesting in spirit of wine aromatic plants, for instance, thyme, lavender, rosemary, &c. a spirituous liquor is obtained, impregnated with the principle of the smell, and with the essential oil of the plants. These spirituous aromatic waters, made by infusion, are the most common in medicine. They are generally colored by a part of the essential oil of the vegetables, which the spirit of wine has dissolved, or by substances of different colors which reside in the remaining matters. These waters have been called *infusions*. *See TINCTURES.*

By distillation is obtained from spirituous distillates a spirit of wine much impregnated with the principle of smell, and with the thinner and most volatile part of the essential oils, but free from all extractive or coagulating matter, because these latter are not sufficiently volatile to rise with spirit of wine. This spirit

Spirit of wine is called by the general name *aromatic spirituous distilled water*, or only by the name of *water* added to the name of the plant employed: hence the names of *lavender-water*, *rosemary-water*, &c. Waters are also made of several plants, and are distinguished by particular names, as *vulnerary-water*, *imperial-water*, &c. These waters are intended for medicine and for the toilette. We may find the details of these preparations in books on pharmacy, and particularly in *Mr. Broussier's Elements of Pharmacy*.

When a tincture has been distilled, we may find at the bottom of the vessel the resinous and extractive part which the spirit of wine had dissolved. These substances have undergone scarcely any alteration, because they have been exposed only to a very mild heat. These are extracts of plants made by spirit of wine. See *Extraction*.

If, instead of subjecting to distillation the spirituous tinctures of vegetables, they be diluted with a large quantity of water, the resinous part may be very well obtained pure and separate from the extractive part. This latter part being equally soluble in water as in spirit, remains dissolved notwithstanding the addition of water, while the former part separates, as we have said, and forms a resinous mass.

By this method are obtained the resins of jalap, of scammony, of guaiacum, and of many other vegetable matters; and these resins, not having undergone the action of fire, are not altered, but remain in the same state in which they existed in the vegetables.

Spirit of wine dissolves also very well certain salts, as sal ammoniac, corrosive sublimate, sedative salt, and perhaps many others which we do not know of; because this matter has not been much examined: but this spirit has little or no action upon other salts, as common salt, Glauber's salt, nitre, concrete volatile alkali, &c. It does not dissolve matters purely gummy and gelatinous, or, at least, it dissolves but a small quantity of them; and as all these matters are very soluble in water, and as water has a stronger affinity with spirit of wine than it has with these matters, hence this spirit may be employed to separate these matters from water. For this purpose we need only to add a good deal of the spirit of wine to the water, which keeps them dissolved: the spirit then seizes the water, and obliges the gummy, gelatinous, and saline parts which it contained in solution to separate from it. The reverse of all this passes in the separation of oils and resinous substances from spirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by seizing upon the water which they contain.

The same may be said of the coagulum formed by mixing spirit of wine with corrosive volatile alkali, dissolved by the smallest possible quantity of water. This coagulum, which is formed suddenly upon the mixture of these two liquors, and which is known in chemistry by the name *Offa Helmontii*, is nothing else than a sudden crystallization of volatile alkali, occasioned by the addition of spirit of wine which seizes the water in which that alkali was dissolved. The same may be said of the crystallization of all salts, which may be successively effected by the means of spirit of wine. See *Crystallization*.

Before that we pass on, concerning the dissolving power of spirit of wine, we may judge of its great utility in chemistry in extractions and separations. It is particularly very useful in the analysis of vegetables and animals by men-

struums.

struums. By reflecting attentively on the properties of this solvent, many analyses and separations which tend to the progress and perfection of chemistry may be improved.

We shall finish this article by some reflexions on the nature of spirit of wine.

Stahl and most chemists believe, that spirit of wine is composed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in spirit of wine than phlogiston united with the aqueous principle by means of an acid.

Lastly, Mr. Cartheuser positively advances, that spirit of wine is composed of pure phlogiston, not in an oily state, but immediately united with the watery principle alone.

This diversity of opinion amongst the ablest chemists proves, that the true principles of spirit of wine are not yet perfectly known. This proceeds from the difficulty of decomposing it without an intermediate substance, and also from several phenomena, some of which seem to shew that it is not a true oil that enters as a principle into the composition of spirit of wine, but phlogiston alone; while others seem to indicate the presence of a true oil existing in the purest spirit of wine.

If we mix the best rectified spirit of wine with water, and if we allow it to evaporate slowly in open air, we shall find upon the surface of the water a certain quantity of oil; and we have seen above, that a true oil may be obtained from spirit of wine by treating it with acids.

But again, if we attend to the essential and fundamental properties of spirit of wine, to its perfect miscibility with water, to its flame, which is not accompanied with any foot or smoke, to the impossibility of reducing it without addition to the state of coal; lastly, to this property, that when it is inflamed we obtain nothing from it but a matter which burns, and pure water, all which properties are not suitable to an oil properly so called, we must acknowledge, that not oil, but pure phlogiston, is the inflammable principle of spirit of wine. We have reason to believe, that the oil which is separated from spirit of wine by water is extraneous to it, and is only contained in spirit of wine, because the means employed to purify this spirit are insufficient to deprive it of all oily matter; and also, that the oil obtained from mixtures of spirit of wine with acids, is evidently an artificial oil, and produced in the operation, as we may see at the word ETHER.

As spirit of wine contains a pure phlogiston very much unaltered, and almost disengaged, it acts upon the nervous system, like all the substances which contain a very volatile and very attenuated inflammable principle. See WATER and PHLOGISTON. It is also very powerfully antiseptic, because it is very successfully employed to preserve from putrefaction matters susceptible of it. It is used topically in gangrenes; and also for the preservation of dead animals, or parts of animals.

*See for the rectification and purification of spirit of wine, RECTIFICATION.*

**DCXLVI SPIRIT of LIBAULT'S.** See LIQUEUR (Smoking).

**DCXLVII.**

**DEXLVII. SPIRIT of NITRE.** Spirit of nitre and nitrous acid are two names for the same thing. For its properties, see **ACID (NITROUS)**. We shall here explain the manner of distilling it, or of decomposing nitre in order to obtain it.

Nitric acid, and several matters containing it, are intermediate substances employed for the separation of nitrous acid from the fixed alkali with which it is united in nitre; because, in general, the former of these two acids is stronger than the latter. In several ways nitrous acid may be obtained by distillation; which however are fundamentally the same, although they vary in some circumstances, according to the nature of the intermediate substance employed, and the required strength of the nitrous acid.

The most frequent method of distilling spirit of wine, especially in great works, is to employ clay as an intermediate substance. As this kind of earth contains nitric acid, it is very proper for decomposing nitre.

Two parts of dry and powdered clay are to be well mixed with one part of nitre. This mixture is to be put into an earthen ware retort, placed in a reverberatory furnace. To this retort a receiver is to be fitted, which is to be well luted, and the distillation is to be promoted by a gradual heat, that is very gentle at first, and raised towards the end so much that the retort shall be very red-hot.

The distillers of aqua fortis use very few precautions, and accordingly their spirit is generally weak and impure. For, in the first place, they employ nitre of the first, or at most of the second boiling, which contains always much common salt. Hence the acid which they obtain is mixed with a considerable quantity of spirit of common salt. It is consequently a kind of aqua regia.

In the second place they do not dry well their clay, by which means their acid is weak; although they always keep apart the most watery part which passes first; this they call *dephlegmating* it.

Lastly, the lute which they use for joining their vessels is only earth formed into a paste with water, a part of which falls into the receiver, especially when they unlute the vessels, and renders the spirit of nitre turbid. But as almost all the aqua fortis which they make is for purposes in which the same accuracy is not required as in chemical operations, this aqua fortis is sufficiently good for the uses for which it is employed.

Distillers of aqua fortis do not use retorts, but stone-ware bottles, with short crooked necks. The receivers are vessels exactly of the same form. Two rows of these vessels are disposed opposite to each other, in an oblong furnace called a *galley*; and a wood-fire is used for the distillation. The operation lasts twelve hours.

Very good, very pure, and even very strong spirit of nitre may be made by the method of the distillation of aqua fortis. For this purpose nitre of the third boiling must be employed; the vessels must be carefully luted with a fat lute composed of dry clay, pounded, sifted and formed into a paste, with a sufficient quantity of boiled linseed oil; lastly, the contained matter must be dephlegmated more than is usual, before the luting is applied. The distillers attend to all these things, when good spirit of nitre is required, and a sufficient price is given. We may observe that spirit of nitre is never so high colored and smoking, when distilled



distilled by means of clay, as when obtained by the other methods, although it may be equally strong.

DCXLVIII. *SPIRIT of NITRE (SMOKING).* Two methods are used in chemical laboratories to obtain a very strong and smoking spirit of nitre. The first is by means of martial vitriol, previously calcined till it becomes red-hot, that all the water of its crystallization may be expelled. Also, very pure nitre of the third or even fourth boiling must be well dried. These two matters are to be pounded and carefully mixed together in equal proportions. They are then to be poured into a good earthen ware retort through a paper funnel, which passes into the belly of the retort, that none of the powder may adhere to the neck of it. The retort is placed in a reverberatory furnace, upon the bars of which is fixed an earthen dish filled with sand. To the retort a large glass balloon, in which is a small hole, is to be fitted and luted with a fat lute. This lute is to be covered with a cloth soaked with another lute made of quicklime slaked in air, and formed into a thin paste with whites of eggs. The whole luting apparatus is to be bound with a string. Then the distillation is to be commenced with a very slow fire. The balloon will soon be filled with red vapors which are condensed there, while another portion of spirit of nitre distills gradually by drops. This distillation is to be continued till the retort is red-hot, and no more vapor is raised.

When the vessels are cooled, they are cautiously to be unluted, and the liquor in the balloon is to be quickly poured into a clean and dry glass bottle, through a glass funnel; which bottle ought to be quickly stopped with a glass stopple. This is the method of distilling smoking spirit of nitre used by Mr. Beaumé; and it is a very good one. The small earthen-dish filled with sand, on which the bottom of the retort rests, is very useful to prevent the too sudden and too unequal application of heat, which would make it certainly liable to be broken. The fat lute of clay and linseed oil is not capable of being injured by acids, and stops very closely. But as it remains always soft, it requires to be held by the linen soaked in lute of lime and whites of eggs.

The vapors of this smoking spirit of nitre are very elastic, and difficultly condensable; for which reason the distillation must be slowly conducted, and must be avoided in hot weather. A brick wall must be interposed betwixt the furnace and the balloon to prevent this vessel from being too much heated; the balloon must be covered with wet cloths frequently renewed, and even the small hole of the balloon must be sometimes unstopped to give vent to the too rarefied and too copious vapors; otherwise the whole apparatus would burst with explosion.

When we perceive that the drops succeed each other rapidly, and that by unstopping the small hole, red vapors dart out the length of a foot or more with a hissing noise; this is a sign that the vessel is ready to burst. The heat then must be lessened, and the small hole must be very frequently unstopped, till the distillation be much moderated.

Lastly, when we pour the nitrous acid into the bottle, we ought to be very careful not to stand in the way of a current of air, because the vapors are very corrosive and noxious. For the same reason also, the mouth of the balloon ought to be stopped as soon as the liquor is poured out of it; for the fumes continue in it more than twelve hours.

**GLAUBER'S METHOD OF GLAUBER'S SMOKING OF NITRE.** Glauber was the first chemist who thought of distilling nitrous and marine acids by means of pure vitriolic acid. By this method we may obtain a nitrous acid highly concentrated, and the process is more easy, quick, and convenient, than the preceding. This distillation ought to be made in the following manner.

Very pure nitre is to be put into a stone-ware or glass retort. Upon this nitre, one-third part of its weight of pure vitriolic acid, rectified, and highly concentrated, is to be poured through a glass funnel, the stalk of which ought to be long enough to go down into the belly of the retort, to prevent any of the acid from adhering to its neck. The apparatus of vessels is to be disposed in the same manner as in the preceding experiment, and the distillation is to be promoted with the same precautions, and with this difference only, that this distillation is sooner finished, and requires a less heat towards the end.

The spirit of nitre distilled in these two latter methods, is the strongest and most smoking that can be obtained. This in Glauber's manner is a little less red and smoking than the other; although it may be as strong, and even more so than the other. The former is rendered so smoking by the phlogiston of the iron of the martial vitriol. Some chemists add some filings of iron in the distillation in Glauber's manner, to render the spirit more smoking.

We may observe, that spirit of nitre obtained by any of these methods is never absolutely pure. It is indeed free from a mixture of marine acid, when nitre perfectly purified has been employed; but we cannot prevent, especially in the distillation in Glauber's manner, some part of the vitriolic acid from rising with it. It must therefore be purified from this acid, when the operations of experiments require a perfectly pure nitrous acid. This purification is easily effected by adding some pure nitre to the acid, and distilling a second time; by which means the small portion of vitriolic acid mixed with the spirit of nitre is made to unite with the basis of the nitre, and is rendered so fixed that it cannot rise in distillation. We may easily perceive, that for this rectification of the nitrous acid much less heat is required than for the former distillations.

All the residuums of these distillations contain a vitriolated tartar, called *sel de duches*.

The residuum of the distillation of spirit of nitre by clay contains a vitriolated tartar mixed with a large quantity of earth, and therefore not easily to be extracted. The clay is baked, hardened, and generally very red, because the clays employed for this purpose are ferruginous. This caput-mortuum forms a very good cement used for pavements. It is used also, for sake of its color, to make compartments, and to vary the colors of sandy parterres. It is called the *marble of Glauber*, or *marble of earth*.

The residuum of the distillation by vitriol contains vitriolated tartar, mixed with a great quantity of the martial earth of this vitriol. Vitriolated tartar may be very easily obtained from it by lotion with water, which is afterwards to be filtered, evaporated, and crystallized. A very red martial earth remains, which is called *marble of vitriol*, or *marble of earth of vitriol*, after it has been sufficiently washed.

We may remark upon this subject, that as the nitrous acid is disengaged from its basis by the acid of vitriol, it ought naturally to be applied to the

martial earth of this vitriol. But as the nitrous acid adheres but weakly to iron, especially when this metal is calcined and deprived of its phlogiston, as it is in this operation, the heat that is employed is more than sufficient to disengage it, and to make it pass entirely in distillation.

Lastly, the residuum of the distillation of spirit of nitre in Glauber's manner, when no iron is mixed with it, forms a very white and very pure vitriolated tartar, which may be dissolved, filtrated, evaporated, and crystallised.

All these residuums generally contain also a little nitre, which not having been sufficiently in contact with vitriolic acid, has escaped its action, and is not decomposed.

DCL. SPIRIT (DULCIFIED) of NITRE. Dulcified spirit of nitre is a mixture of one part of nitrous acid with two parts of rectified spirit of wine, digested together. (u)

As nitrous acid acts powerfully on spirit of wine, it is rendered considerably milder by this mixture. It is used only medicinally, and is considered as aperitive, and powerfully diuretic. It is added by drops to potions and juleps, till it has given an agreeable acidity.

DCLI. SPIRITUS RECTOR. The *spiritus rector* is a very attenuated, very subtle principle, in which the smell of all odoriferous bodies peculiarly resides.

To obtain the *spiritus rector* from odoriferous substances, these matters are to be distilled in the cucurbit or body of an alembic placed in a water-bath, with a very gentle heat, that is, from thirty to thirty five degrees of Mr. Reaumur's thermometer, till we perceive that what rises in distillation has little or no smell.

The principle of smell in bodies is in general too subtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly it rises by means of the water contained in substances distilled in order to procure it, and is dispersed and overwhelmed in water. If the odoriferous matters from which the *spiritus rector* is required to be procured, were absolutely dry, and contained no other volatile principles, a little water or spirit of wine ought necessarily to be added, to furnish a kind of basis to this spirit, which would otherwise be dissipated and evaporated, so that it could not be collected.

This principle of the smell of bodies is miscible with water, with spirit of wine, and with oils. It seems however to be of different natures, according to the substances which furnish it. Its properties shew that it is in general composed of an inflammable principle, and of a saline substance, both extremely attenuated. But the *spiritus rector* of some substances appears to be more of a saline, and that of others more of an oily nature.

All matters, the smell of which is quick, pungent, and which do not affect the brain and nervous system, as the acrid, cruciform plants, and substances which undergo the acid fermentation, contain a *spiritus rector* probably more saline than oily.

Those on the contrary whose smell is sweet, nauseous, or strong, without acrimony or pungency, and which affect the head, by curing or occasioning hysterical or convulsive accidents; such are ambergris, musk, castor, burnt

(u) The London and Edinburg Dispensatories direct that the mixture should be distilled. This operation ought to be performed with a very slow, and gradually raised fire, that explosions may be prevented.

coffee,



coffee, opium, narcotic plants, camphor, all aromatic plants, and lastly, the substances which undergo the spirituous fermentation; have, according to all appearance, a spiritus rector, which partakes of the nature of oil. For besides that the effects produced by these substances are similar to those of the vapor of charcoal, the spiritus rector of some of them is really inflammable; as, for instance, that of *fraxinella*, the exhalations from which form an atmosphere that may be inflamed with a lighted taper.

The spiritus rector of all aromatic plants seems particularly to be associated with their essential oils; at least, all these oils contain a good deal of it. To this principle they certainly owe their smell, and probably their volatility and thinness; for those which from age, or from not having been preserved in well closed vessels, have lost their proper smell, are at the same time much less thin and volatile, since they are no longer capable of being raised by the heat of boiling water; and besides, the plants from which the spiritus rector has been obtained, furnish little or no essential oil. See OILS (ESSENTIAL)

The spiritus rector, even that of aromatic plants, although it be of an oily nature, is perfectly miscible with water; which can only proceed from its great tenuity, or from the saline principle which enters its composition.

DCLII. SPIRIT of SALT. The spirit of salt, or acid of common salt, can only be obtained by means of a sufficiently powerful intermediate substance, to disengage it from the native fixed alkali, which is the basis of common salt. Vitriolic acid is the most proper and most useful intermediate substance for the distillation of spirit of salt. It is employed, either engaged in a basis with which it has a less affinity than with that of common salt; or pure, in order to obtain Glauber's smoking spirit of salt.

Ordinary spirit of salt is distilled by the mixture of one part of common salt with two parts of dried clay, precisely in the same manner as we have described for the distillation of spirit of nitre. See SPIRIT of NITRE. The spirit of salt obtained by this method is white and not smoking, although it may be considerably strong, if the salt and clay have been previously well dried.

We may observe, that a smoking spirit of salt cannot be obtained by means of martial vitriol, calcined till it becomes red, as is practised for the spirit of nitre. I have tried to make this distillation; and although a very violent heat was applied, but very little marine acid was procured. The true reason of this difference is, that marine acid dissolves much more easily than nitrous acid, metallic earths deprived of their phlogiston, and adheres to them much more strongly. Hence, as soon as the marine acid is disengaged from its basis by the acid of vitriol, it applies itself to the martial earth of this vitriol, which retains it with much more strength than it is capable of retaining nitrous acid.

DCLIII. SPIRIT (GLAUBER'S SMOKING) of SALT. To have the strongest and most smoking spirit of salt, we are obliged to employ as an intermediate the pure vitriolic acid, as Glauber has practised. But this operation, especially when we would have spirit of salt highly concentrated, is very difficult and laborious, because the vapors are much more difficultly condensable than any others. The following is the process successfully practised by Mr. Beaumé.

Common salt is put into a tubulated stone-ware or glass retort, which is to be placed in a furnace for distilling; and to this retort a balloon is to be

fitted, exactly in the same manner as for the distillation of smoking spirit of nitre. See SMOKING SPIRIT of NITRE. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glass funnel, a quantity of rectified vitriolic acid previously diluted with a little water, equal to a third part of the weight of the salt, is to be poured at several different times, and the opening is to be closed each time immediately after a part of the acid has been added.

As soon as the vitriolic acid is added, we see white vapors passing from the retort into the receiver. These are the smoking spirit of salt which this acid disengages, even without fire; for which reason these first vapors ought to be allowed to pass, before the fire be kindled; which ought not to be done till they are considerably diminished, otherwise the distillation would go on too fast at first, and the vessels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is necessary to continue the distillation. Lastly, the distillation is to be conducted to the end with the same attentions which we directed for smoking spirit of nitre; and when it is finished, the spirit of salt is to be collected in the same manner.

Between this process and that, by which a smoking spirit of nitre is obtained in Glauber's manner, two essential differences may be perceived. The first is, that in this distillation the vitriolic acid is not added till the vessels are arranged and luted; and hence a tubulated retort is necessary. The reason of this is, that vitriolic acid disengages the acid of common salt without heat, and as soon as it touches this salt; and that the vapors which pass out copiously from the retort, by keeping the neck constantly wet, render the application of the lute impossible. When the lute happens during the distillation to be deranged, it cannot be again repaired. The shortest method then is to discontinue the operation, and begin again.

The second difference between the distillation of smoking spirit of nitre and smoking spirit of salt by means of vitriolic acid, is, that water is added in the latter distillation, and not in the former. The reason of this is, that the vapors of concentrated marine acid are so much more difficultly condensable than those of nitrous acid equally concentrated, that if well concentrated vitriolic acid, and decrepitated common salt, be employed, almost all the marine acid would be dissipated in vapors which would be lost, and scarcely a sensible quantity of liquor would be obtained. See ACID (MARINE) for the properties of spirit of salt, and SALT (COMMON).

The residuums of the distillations of spirit of salt contain Glauber's salt. In that of the distillation by means of clay, this salt is confounded with much earth, and difficultly obtainable. But the residuum of the distillation by vitriolic acid is pure Glauber's salt. This salt appears a white saline mass at the bottom of the retort. It ought to be calcined in a crucible, that any remaining acid may be expelled. It is then to be treated by solution, filtration, and crystallization.

By this distillation, Glauber first discovered the salt which he afterwards examined, and called *sal mirabile*. This name is still continued; so that it is now called *sal mirabile*, *sal mirabile Glauberi*, or *Glauber's salt*. See SALT of GLAUBER.

DCLIV. SPIRIT (DULCIFIED) of SALT.  
Dulcified.

Dulcified spirit of salt is made by mixing this acid with twice its weight of rectified spirit of wine, and digesting this mixture during a month.

As this acid has much less disposition than the vitriolic and nitrous acids to combine with inflammable matters, it cannot be so well dulcified as they can by spirit of wine.

Authors differ much concerning the methods of dulcification. The proportions are from two to five or six parts of spirit of wine to one part of spirit of salt. Some authors do not say whether the spirit of salt ought to be concentrated and smoking, or not; others require that a smoking spirit should be employed. Lastly, some direct the distillation of the mixture, and others are contented with a simple digestion. But in whatever manner the operation is performed, the acid remains crude, and not much dulcified: hence dulcified spirit of salt is not used in medicine; for its virtues do not essentially differ from those of dulcified spirit of nitre, which is infinitely milder.

Marine acid, although very concentrated and very smoking, does not produce, when mixed with spirit of wine, but a very inconsiderable heat and effervescence, and much inferior to those occasioned by vitriolic acid, and still more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of spirit of wine.

These two substances are but little altered by being mixed together: for Mr. Pott having combined a dulcified spirit of salt with an alkali, obtained a *regenerated sea-salt*, which decrepitated upon hot coals, and precipitated lead and silver from their solutions in nitrous acid into corneous metals. Nevertheless, we are certain that a part of the marine acid contracts an union, and even an intimate union, with spirit of wine: for Mr. Pott relates, that having distilled to dryness the thick matter remaining after the most fluid and volatile part of the mixture had been separated, he found a black, residuous coal, which cannot be obtained by distilling any of these two matters separately. See ETHER (MARINE).

DCLV. S P I R I T of S U L P H U R. Spirit of sulphur is nothing else than vitriolic acid obtained from sulphur by burning.

As sulphur cannot furnish its acid but by burning, and as it cannot burn but in open vessels and free air, we can therefore obtain but a small quantity of acid by this method.

Before the acid of sulphur was known to be the same as ordinary vitriolic acid, a spirit of sulphur was prepared with great expence and trouble, upon the supposition that it had peculiar properties. For this purpose, sulphur was burnt in an open crucible, placed upon a stand in an earthen dish filled with hot water. A large capital or glass-bell was suspended above this dish. The acid of the burning sulphur meeting the vapor of the hot water, united with this water, and fell down along the sides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at present this operation is only performed to shew, that the acid contained in sulphur is not decomposed during combustion, and that it is only one and the same thing with vitriolic acid.

The true method of obtaining much acid of sulphur is to burn it in close vessels

vessels by means of a small quantity of nitre, as it seems to be practised in some places. See *CLYSSUS*. (x)

**DECVI. SPIRIT of VENUS.** This name is given by chemists to the acid of vinegar highly concentrated, obtained by distilling verdegrise, or crystals of verdegrise, or of Venus, which are nothing else than combinations of copper with acetic acid.

The operation by which spirit of Venus is obtained is very easy. Nothing more is required than to put verdegrise, or crystals of verdegrise, into a retort, one third part of which ought to remain empty, as is usual: to this retort a receiver is to be adjusted, and the distillation begun with a very gentle fire: the first portions of liquor which pass are to be set apart, as they are nothing but phlegm: the distillation is to be promoted, by gradually augmenting the fire, till the retort begins to be red-hot, and nothing escapes from it.

The acid of vinegar passes in this distillation partly in white clouds, and partly in drops. This acid is very strong; because in general acids which are combined with any body whatever, are by that means deprived of all their superabundant water. Besides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be easily dephlegmated in the beginning of the distillation.

The spirit of Venus has a very vivid pungent smell, almost as suffocating as volatile sulphureous acid. The Count de Lauraguais discovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like spirit of wine, and leave no residuum. This experiment, added to the observations made by Beccher and Stahl upon the production of vinegar, shew, that spirit of wine enters as a constituent part into the composition of this

(x) The greatest part of the vitriolic acid now employed is obtained by burning sulphur. The vapors of burning sulphur are the volatile, vitriolic, or sulphureous acid. These are very difficultly condensable. For which reason, very large vessels and much time are required in this operation. Some artists use leaden, and others use glass vessels. The bottom of each of these vessels is covered with a little water to assist the condensation of the vapor. Above the water is placed a small vessel capable of containing a few pounds of sulphur, to which a small portion of nitre is added by some artists, because by this addition, a larger quantity of sulphur may be burnt without access of fresh air. The vessels are to be filled with the vapor of hot water, and their sides wetted with the condensed steam: then the sulphur is to be kindled by touching it with a red-hot iron: the vapor of the burning sulphur rises slowly; and when it has risen as high as the mouth of the great vessel, this must be stopt, or

very nearly stopt, that the vapor may be confined. The sulphur continues to burn till the air contained within the vessel and the nitre be no longer capable of maintaining the combustion. The vapor remains a considerable time before it be entirely condensed, notwithstanding that this condensation is facilitated by the water in the vessel, and especially by the steam of water with which the vessel was previously filled. When all the vapor of the sulphureous acid is at last condensed, the sulphur is to be again kindled, and more added if it be necessary, and the process repeated as before. When a sufficient quantity of acid is collected, it is to be taken out of the vessel; and after it has lost its sulphureous or volatile quality by exposure to air, it is concentrated and rectified by distillation. See *ACID (VITRIOLIC)*, *ACID (VOLATILE SULPHUREOUS)*, and *CONCENTRATION of VITRIOLIC ACID*.

acid.

acid. The Count de Lauraguais also observed, that spirit of Venus well concentrated, easily crystallizes without addition; and this observation has been since confirmed by the Marquis de Courtauvau. See FERMENTATION (ACID), and VINEGAR.

As the last portions of the acid of vinegar adhere pretty strongly to the copper in the verdegrise, and to the crystals of Venus; and as we are obliged to give a strong degree of heat to expell them, they then raise along with them a small quantity of this metal, which gives a greenish color to the spirit of Venus: but it is easily freed from these cupreous parts by a second distillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongst others, those of forming ether when distilled with spirit of wine. See ETHER (ACETOUS), and VINEGAR (RADICAL).

We must observe, that when verdegrise is employed for the preparation of spirit of Venus, we obtain very little of this spirit, and that it is more oily than when it is obtained from crystals of verdegrise, which furnish nearly one half of their weight of the spirit.

After this distillation, we find in the retort the copper which had been the basis of the crystals of verdegrise. This copper is divided into very small parts, which, however, are agglutinated into lumps that are very friable. Its color is blackish, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decomposed towards the end of the distillation. Mr. Beaumé observes, that this coal is easily kindled by the application of fire, and burns, like tinder, upon the surface of the copper.

This copper, not having lost any of its phlogiston, may be easily fused into an ingot of red copper. We ought only to add a little black flux, to prevent or repair the calcination which may be made during its fusion.

DCLVII. SPIRIT of WINE. See SPIRIT (ARDENT).

DCLVIII. SPIRIT of VINEGAR. See VINEGAR (DISTILLED).

DCLIX. SPIRIT of VITRIOL. This name is given to the first portions of phlegmatic vitriolic acid which pass in the distillation of vitriol, or in the concentration of vitriolic acid. The name is given in general to every dilute vitriolic acid.

DCLX. SPIRIT (VOLATILE) of SAL AMMONIAC. The volatile spirit of sal ammoniac is the volatile alkali that is the basis of sal ammoniac, and that has been disengaged by means of some intermediate substance, which also has taken from it some of its oily principle, by means of which it was capable of a solid or concrete state; hence this spirit is always liquid.

The intermediate substances which have the property of producing this alteration upon volatile alkali are stony and metallic calxes. If two parts of quicklime slaked in the air, or of minium, be mixed together with one part of sal ammoniac, and if this mixture be distilled, a fluor volatile alkali will be obtained in form of a very quick and penetrating spirit.

Mr. Schlosser, in his Dissertation on the Fusible Salt of Urine, says, that the volatile alkali which serves as a basis to the phosphoric acid in this salt is always fluor, whether it be disengaged by fire alone, or by any intermediate substance;

substance; and that concrete volatile alkali combined with this acid can never afterwards be obtained but in a fluor state; which shews, that the phosphoric acid has the property of taking from volatile alkali the matter by means of which it is crystallizable. See for the properties of volatile spirit of sal ammoniac, ALKALI (VOLATILE), and AMMONIAC (SAL).

DCLXI. S T E E L. Steel, considered chemically, is nothing else than iron reduced by art to a particular state, which occasions some changes in its properties; but these properties are essentially the same as those of iron; that is, iron and steel are not two different metals, but the same metal in two different states: therefore all the fundamental properties of steel are mentioned under the article IRON. We shall here only describe the method of making steel, explain the theory of that operation, and mention its differences from those of iron.

Stahl, Cramer, and all good chemists, justly consider steel as an improved iron, which is possessed of a larger quantity of inflammable principle, so necessary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We shall be convinced of this truth by a description and explanation of the methods of converting iron into steel, and by examining the characteristic properties of steel.

Steel may be made by fusion or by cementation. The first method is used to convert iron into steel immediately from the ore. All ores of iron are not used indifferently for this purpose, because some of these, which are therefore called *ores of steel*, are much fitter than others to furnish good steel; and the steel extracted from them is called *natural steel*.

The other method of making steel consists in chusing the best forged iron, or that which is most malleable, whether it be hot or cold; and in impregnating this iron with a larger portion of inflammable principle, by cementation alone, without fusion.

To understand well these methods of making steel, we must attend to two essential properties of iron. The first is, that of all metals it is the most difficultly fusible; and that therefore although in the smelting of its ores its fusion be much assisted by the sulphureous parts of the ore itself, yet, as these parts are always expelled as much as is possible, iron never enters into so thin and perfect a fusion as the other metals.

The second property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metallised without fusion.

These things being premised, it happens, in consequence of the former property, that, in the first fusion of ores of iron, we obtain only a hard and brittle iron, both from the sulphureous parts from which this iron is not entirely disengaged, and from the presence of a greater or less quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metallised, from want of immediate contact with the phlogiston of the fuel.

We may easily perceive that these earthy parts, unmetallic or not metallised, cannot be entirely separated from the perfect iron, because the fusion is not sufficiently thin for that purpose: but in proportion as the iron is deprived of sulphur, its fusion becomes more and more difficult, and we are obliged to have recourse to another expedient than fusion to disengage it from its earthy parts,

parts, which in the first smelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and struck by a very heavy hammer.

This percussion, that iron softened by heat sustains, presses strongly, and folders or welds together the metallic parts, which only are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to separate. By this operation these unmetallic parts are pressed between the parts of the iron, and driven by degrees to the surface of the metal, from which they are detached in form of dust and scales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The operations by which steel is to be extracted from its ores are essentially the same as these employed for iron; but they differ from them in being much more exact; that an iron still purer, more filled with phlogiston, and better disengaged from its earthy parts, may be obtained.

To succeed in this intention, much smaller quantities must be fused at once than when iron is to be extracted from its ore. Pieces of the first fusion are to be put into crucibles filled and covered with charcoal, and exposed to a violent heat excited by strong bellows. These pieces are to be well fused, and kept in fusion a longer or shorter time, according to the nature of the ore; after which, they are to be forged, as iron is, but always in much smaller pieces, and till they are become perfectly ductile both when hot and when cold. Nothing then remains but to temper the steel, of which we shall presently speak.

In these operations, which are to be several times repeated, the iron that is changed into steel must evidently be much better purified, and furnished with a much greater quantity of inflammable principle, than in the smeltings and fusions of large quantities of iron. As the masses of metal are small in these operations for the procuring of steel, and as they are surrounded with a much larger proportion of charcoal, the fusion is not only more compleat, by which the separation of the earthy unmetallic parts is much promoted, but also a greater number of ferruginous parts are well metallised; and as all these parts of iron are in more intimate contact with the charcoal, which is capable of supplying them with inflammable principle, they receive the whole quantity of this principle, with which they can unite.

The same observation may be applied to the operation of the forge practised upon smaller masses; for the heterogeneous parts are much more easily and copiously pressed out of small masses than great.

This exact purification of iron, by which it is converted into steel, must evidently be attended with considerable loss, or diminution, from the separation of all its heterogeneous parts. This diminution amounts to nearly one half of the weight of the iron. This great loss does not proceed altogether from the separation of heterogeneous parts; for in all the operations used for this separation, some part of the metal is always destroyed and burnt, although all possible precautions are taken to diminish this inconvenience, by securing the melted or red-hot metal from the contact of external air as much as is possible.

*Artificial steel* is made without fusion from iron ready forged. The chief point to be attended to in the making of the best artificial steel, is to chuse the iron which is most perfect and most malleable, either when it is hot or cold; which quality always shews that the iron is well purified. It is first to be forged into plates or bars, rather small than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compose this cement vary according to the uses of different manufactures. They are all good, provided they contain no sulphur, or vitriolic acid, which might form sulphur during the operation; because sulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuse it, and would, by reducing it to a mineral or pyritous state, give to it qualities very different from those which good steel ought to have.

The matters which enter into the composition of the cement for steel, are the coals of animal or vegetable substances mixed with ashes, calcined bones, and other matters of this kind. Mr. Cramer proposes the two following receipts of cements for steel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-ashes, and mix them very well together: or,

Take two parts of charcoal, moderately pulverised; one part of bones, horns, hair or skins of animals, burnt in close vessels to blackness, and powdered; half a part of wood ashes, and mix them well together.

When steel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a stratum of the cement of about the thickness of a finger has been previously put and pressed down. The bars ought to be about an inch distant from each other, and from the sides of the crucible. The interstices and crucible are then to be filled with cement, so that the bars shall be covered with about the thickness of two inches at least. The crucible, previously covered with a lid which fits it exactly, and which must be carefully luted with clay mixed with sand, is to be placed in a furnace where an equal fire is to be kept; so that the crucible shall be red-hot during eight or ten hours: the iron will then be found to be converted into steel, which will be so much better as the iron employed was of a better quality: it then only requires to be tempered. We may observe, that in this operation the iron suffers no diminution of weight, and no scoria appears upon its surface, as Mr. Cramer remarks. By the sole addition, therefore, of a new quantity of phlogiston, the iron acquires the quality of steel. Thus, if this iron contained some parts of martial earth which was not metallised, by the cementation they are metallised, and the iron or steel are thereby improved: but if the iron contained some earthy unmetallised parts, they are not separated by this operation, because the metal has not been fused; and as the best forged iron which is usually sold is never so well purified from these extraneous matters, as that which is converted into steel in the great works for procuring steel from the ore of iron; hence, in general, artificial steel made by cementation is not so perfect as that made by fusion.

We may observe that, in the cementation above described, the iron combines with a part of the phlogiston of the cement, without fusion; which effect proceeds from a peculiar property of the earth of iron by which it is capable of com-



combining with the inflammable principle, and of being metallised without fusion, which is, nevertheless, necessary for the reduction of all other metallic earths.

The steel which has received only the above-mentioned preparations differs from iron in its color, which is more dark and brown; in its grain, which is finer and closer; in possessing a greater ductility, flexibility, and softness: but the great difference of steel from iron, which renders it more valuable for many purposes and arts, is the extreme hardness it acquires by being tempered.

This operation is very simple. It consists in making steel red-hot, and then in plunging it suddenly in cold water. In an instant all the qualities of this steel are changed by this tempering; so that from being very ductile and soft, it becomes so hard and so stiff, that it is no longer capable of being cut by the file, but is itself capable of cutting or piercing very hard bodies; that it does not yield to the hammer, but may be sooner broken in pieces like a flint, than be extended. It is sonorous, brittle, very elastic, and capable of acquiring the most lively and most beautiful polish, as we see in finely wrought toys of steel.

The use of this metal is very extensive for numberless convenient and necessary utensils of all sorts, of which without it we should absolutely be deprived: but what renders its use still more general is, that we can diversify at pleasure its hardness and ductility, by varying the temper. The hotter the steel is when tempered, and the colder the water into which it is plunged, the greater hardness it acquires; but, at the same time, it becomes so much more brittle. This very hard temper is necessary for certain tools designed to cut very hard bodies. On the contrary, the less hot the steel is when tempered, and the hotter the water is in which it is tempered, the less hard it becomes, and also the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are less liable to have their points broken, or their edges notched, than if they were made of a harder steel.

No other general rule can be given for the tempering of steel than that we have mentioned. The proper degree of heat is always relative to the use to which the tools to be made of this steel are to be applied.

Another very convenient property of steel is, that after it has been tempered, it may be again untempered and softened to any degree that we think proper. For which purpose we have only to heat it more or less, and to let it cool slowly. By this method we may soften the hardest-tempered steel.

As the temper is a very essential point with regard to steel, and that the best is in general that which gives the greatest hardness, and destroys the least of the ductility of the metal, various substances are used, into which steel to be tempered is plunged. Such are suct, oil, urine, water impregnated with foot, with sal ammoniac, or with other salts. These particular methods are the bases of many secrets in different manufactures; their advantages cannot be ascertained without a very accurate and continued examination. Very interesting researches remain to be made on this subject.

Steel is usually sold tempered, because, in many manufactures of it, the custom is to temper it as soon as it is made, probably that the purchasers of it may be better able to judge of its quality. When this steel is to be used, it

must be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we also find amongst merchants English steel in small bars, which is not tempered, and which is very good.

Well polished plates of steel, put on a gentle fire of charcoal, acquire different colors on their surface, and pass successively through several shades, as they become hotter, in the following order, white, yellow, orange, purple, violet, and lastly, blue, which disappears and leaves a water-color, if the steel has been heated too much or too long. These different shades mark the degree of heat or of annealing applied to different tools or utensils. The most generally used shade is the blue, such as that given to steel springs.

One of the most important properties of steel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compasses cannot be made without needles of steel.

From what we have said, we may judge that steel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philosophers, but who were not chemists, have advanced, that steel was only iron which still retained something of its mineral nature, and that its state was intermediate betwixt that of cast iron and soft forged iron. But this opinion is manifestly erroneous. They have been deceived by the hardness and brittleness of cast iron, which are nearly as great as in steel. But these qualities proceed from a remaining part of the mineralising substances, which leave it a pyritous character, very different from that of true steel, since this can only be hardened by the temper, and since in the preparation of it all sulphureous matter must be carefully avoided. The mistake of these authors proceeded from their ignorance of the inflammable principle, the properties of which have been so well explained by the illustrious Stahl, and from their being led into an error by the old chemists, who perpetually confounded phlogiston, or the purest and simplest inflammable principle of all bodies, with sulphur, with sulphureous matters, and with most other inflammable compounds.

Steel may be un-made, or reduced to the state of iron, by a management similar to that by which it is made, that is, by cementation. But the cement used for this purpose must be composed of substances entirely free from inflammable matter, and rather capable of absorbing it, as calcareous earth and quicklime are. By a cementation then with these matters continued during eight or ten hours, steel is reduced to the state of iron.

Stahl considers it as an undecided question, whether steel be more fusible than iron, and says, that the workmen cannot decide it from the violence of the necessary to melt either of them. He believed with reason, that this question might be decided by melting these metals in the focus of a burning speculum. Mr. Macquer says, that by this method he found steel much more fusible than iron (y). This greater fusibility of steel can be only attributed to

(y) Soft forged iron can scarcely without addition be brought into perfect fusion by the heat of our furnaces, till the phlogiston of the fuel has converted it into steel. But steel is daily melted and cast into ingots, called *cast-steel*, by which it is rendered more uniform and similar in all its parts, and thereby fitter for being wrought into the finer kinds of utensils for which steel is employed. This cast-steel, when again reduced

the greater quantity of phlogiston united with it, as phlogiston is in general the cause of the fusibility of metals. (z)

duced to the state of forged iron by cementation with absorbent earths, is the most uniform, equal, perfect iron which can be obtained.

(z) By conversion of iron into steel, this metal acquires a closer, more compact and finer-grained texture, greater hardness, elasticity, tenacity, sonorousness, and disposition to receive the magnetic property; and, as is said, a greater gravity, both absolute and relative. It is also rendered less liable to rust by exposure to air; and less liable to emit sparkles when heated. The colors or irises which steel acquires by exposure to heat, and which are marks by which workmen know when any required heat is given, are not peculiar to steel and iron, but may also be produced by the same means on all other calcinable metals. These colors proceed from a calcination gradually advancing on that part of the metals which is exposed to air. And as the particles of metals in their different degrees of calcination are probably of different sizes, so they must acquire (according to Sir Isaac Newton's theory, which shews that the colors of bodies depend on the size of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fusion, or by cementation with inflammable matters. Anciently steel is said to have been made by immersing forged iron during some time in melted crude iron. Forged iron may also be changed into steel, as Wallerius affirms, by immersion in melted scoria; or by fusion with black flux, glass-gall, or borax; or by strewing sea-salt upon heated iron, and extinguishing it in dung.

Various opinions are formed concerning the cause of the difference between iron and steel. The most general opinion attributes this difference to the presence of a larger quantity of phlogiston in the latter than in the former. Some authors, attending chiefly to the method of conversion by fusion, consider that operation only as a purification of the iron from earthy and heterogeneous particles, and steel merely as a more pure and perfect iron. Others, observing some

similitude in the texture of steel to certain kinds of cast iron, and the hardness of both these, without attending to their essential differences, have imagined that the state of steel was intermediate betwixt that of cast and that of forged iron. Lastly, some metallurgists maintain that the conversion of iron into steel is effected not by absorption of phlogiston, but by expulsion of sulphureous or acid particles. To support this opinion, they observe, 1. That steel is less disposed than iron to rust; the cause of rust being, as they think, an acid contained in iron; 2. That steel emits fewer sparkles under the hammer than iron, which sparkles are found to be most frequent in iron abounding with sulphur, as in red-short iron; 3. That iron may be converted into steel by cementation with alkaline salts, capable of attracting the acid and sulphur; 4. That in the preparation of steel by fusion, the metal is rather exposed to a dissipation of its inflammable parts and burnt; than further phlogisticated; and that this operation is accordingly called by workmen *the burning of steel*.

In the preparation of steel by fusion, probably much of the earthy matters contained in the iron may be separated, and any contained acid or sulphur may be burnt or dissipated. But the conversion of steel into iron by cementation with absorbent earths, in which operation no acid or sulphur can be absorbed by the metal, shews that the difference between iron and steel does not consist in the presence of an acid or of sulphur in the iron, but in the presence of some substance in the steel, which the inflammable cementing substances can give to it, and of which absorbent earths can deprive it. This substance has been, with great probability at least, believed to be phlogiston; by the addition of which the metal acquires a new texture, together with the hardness, elasticity, and other peculiar properties of steel: we doubt not, however, that in the operations for making steel, by fusion or by cementation, any contained acid or sulphur may be expelled, and thus the metal may be meliorated, and rendered less liable to rust and to emit sparkles.

The affinities and medicinal virtues of steel are the same as those of iron. *See* IRON.

DCLXII. **STONE S.** This name is given in general, both in chemistry and in natural history, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *stones*.

As many different kinds of stones as of earths may be distinguished. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form stoney bodies. But as this union of the integrant parts of any earth does not really change the nature of this earth; and as it always has the same essential properties, especially when considered chemically; we refer to the word EARTH for all that we have to say concerning stones. The origin, and the sensible qualities by which naturalists distinguish different kinds of stones, are treated of in *Mr. Bomare's Dictionary of Natural History*.

Several chemical preparations are also called stones, of which we shall here treat.

DCLXIII. **STONE (CAUSTIC), or COMMON CAUSTIC.** *See* CAUSTIC.

DCLXIV. **STONE of BOLOGNIA.** This stone has been much celebrated for the property it has of becoming phosphoric by calcination. It is a heavy selenitic spar. All spars of that kind, and also several other stones, have the same property. *See* PHOSPHORIC (STONES), and SPARS.

DCLXV. **STONE (INFERNAL), or LUNAR CAUSTIC.** *See* CAUSTIC (LUNAR).

DCLXVI. **STONE (PHILOSOPHER's).** This name is given by alchemists to the preparation, by which metals may be transmuted, gold and silver made, and all the wonders produced of (what they call) the *great work*. *See the articles* METALS and METALLISATION.

DCLXVII. **SUBLIMATION.** Sublimation is an operation by which volatile and solid substances are collected and obtained.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all we have said on the article DISTILLATION is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases; for instance, to combine two volatile matters; as in the operation of the sublimates of mercury; or to collect some volatile substances; as *sedative salt*, *sulphur*, and all the preparations called *flowers*.

The apparatus for sublimation is very simple. A matrafs or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire vary according to the nature of the matters which ought to be sublimed, and according to the form which ought to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts; such as almost all those called *flowers*; as *flowers of sulphur*, and of *benjamin*,

*benjamin, sedative salt, and others of this kind.* When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are to be employed. The sublimation is performed in a sand bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed; and the capitals are to be guarded as much as is possible from heat. The height of the cucurbit and of the capitals is well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations a certain quantity of some liquor is raised, as happens in the sublimation of sedative salt, and in the rectification of volatile concrete alkalis, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak, and a receiver.

Some sublimates are required to be in as solid and compact masses as their natures allow. Of this number are camphor, sal ammoniac, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasies, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art therefore of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand, (that is, making it cover more or less of the matras) that the heat in the upper part of the matras shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time, this heat must not be so great as to force the sublimate through the neck of the matras, and dissipate it. These conditions are not easily attained, especially in great works.

Many substances may be reduced into flowers and sublimed, but which require for this purpose a very great heat with the access of free air, and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most roots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This process is called *sublimation in the manner of Geber*. The *tutty, calamine, or pompholyx*, which are gathered in the tops of furnaces in which ores are smelted, are sublimates of this kind.

**DCLXVIII. S U B L I M A T E (C O R R O S I V E).** This preparation, called also *mercury corrosive sublimate*, is a mercurial salt, in which mercury is united with the largest quantity of marine acid with which it is capable of combining intimately.

This salt is called *sublimate*, because it can only be well prepared by sublimation; and it is called *corrosive*, because it is one of the most corrosive salts or even the most corrosive of all salts with metallic bases.

Corrosive sublimate may be made by several processes, which, however, are all so contrived, that the vapors of mercury and of marine acid shall meet in the same subliming vessel.

The most usual method consists in mixing well nitrous mercurial salt with vitriol of iron and common salt, all well dried; and in promoting the sublimation, as we have said under the article MERCURY.

Another process consists in dissolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white saline mass remaining after this solution, previously dried, with an equal weight of dried sea-salt; and in subliming this mixture in a matrafs with the heat of a sand-bath, by encreasing the fire till nothing more is sublimed. This process is given by Mr. Boulduc, in the *Memoirs of the Academy for the Year 1730*. Mr. Spielman observes, in his *Chemical Institutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial salt quits the mercury to unite with the alkali of common salt, to which it has a greater affinity, and with which it forms a Glauber's salt, that remains at the bottom of the matrafs after the sublimation; while the marine acid on the one side, and the mercury on the other, being both disengaged, are reduced into vapors by the effect of heat, unite strictly together, and form the corrosive sublimate, which attaches itself to the upper part of the matrafs. This sublimate consists partly of a white, semi-transparent, saline mass, and partly of shining crystals, composed of small and pointed plates.

This method of making corrosive sublimate is well-contrived, and seems preferable to the ordinary process; 1. Because the mercury, being previously dissolved by vitriolic acid, is as easily and perfectly mixed with common salt in this as in the ordinary process. 2. Because the acid of the vitriolic mercurial salt disengages powerfully and plentifully the acid of common salt; and that it is necessary, as we shall see, that the mercury should meet all the quantity of marine acid with which it is capable of uniting, to obtain the most corrosive sublimate. 3. The process of Kunckel and Mr. Boulduc is more simple than that with vitriol; the operator is less exposed to the acid vapors, the mixture from which the sublimate is separated is less voluminous, and therefore this method is justly preferred.

We think we ought to observe, upon the subject of this process, that almost all chemists, who have mentioned it since Mr. Boulduc, say, that it is made from a mixture of turbith mineral with common salt. This is an inaccuracy capable of leading readers into a mistake; for the vitriolic mercurial salt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very necessary in the operation; whereas *turbith mineral* contains very little or no vitriolic acid, when it has been well washed, according to Mr. Beaumé's experiments; and consequently if *turbith mineral* be employed with common salt, in the proportions directed by Mr. Boulduc, we should obtain no sublimate, or but a very small quantity of a sublimate, which would not be corrosive.

The saline sublimate of mercury may be obtained by several other processes; for instance, the vitriol of the ordinary mixture may be omitted; we might also employ crude mercury instead of the mercurial nitre, and triturate it a long time with vitriol and salt, as Lemery says, or sublime the *white precipitate* alone. But we shall say no more of these methods, because they are all inferior to those we have mentioned, when a very corrosive sublimate is required; altho' some

some of them, as the sublimation of white precipitate, be very convenient, and may furnish a sublimate which probably is very good, when it is intended to be afterwards converted into *sweet mercury*, or *mercurial paracea*. But we must mention another method of making this saline sublimate of mercury, proposed also by Lemery, because it is founded on a mistake which ought to be made known.

This method consists in triturating crude mercury with twice its weight of common salt; and in subliming this mixture, from which, according to Lemery, may be obtained a white sublimate, less corrosive indeed, as he acknowledges, than the ordinary sublimate, but which, nevertheless, is corrosive.

What Lemery says upon this subject is certainly true; but a modern author infers from thence, that mercury decomposes common salt, that marine alkali has not a stronger affinity than mercury with marine acid, and that this experiment contradicts established affinities. But none of all these consequences is justly deducible. We explain this kind of paradox in the following manner.

For this purpose we must previously know, 1. That common salt, even when crystallized very regularly, is not a pure, homogeneous salt; but that it is intimately mixed with another salt, composed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine salt, with calcareous basis, escapes merely by the action of fire, and without any other intermediate substance than a little moisture. 3. That when mercury is sublimed with ordinary common salt, that is, common salt which has not been purified from the mixture of this salt with calcareous basis, it combines with the acid of this latter salt, and not with that of the true common salt, and forms a mercurial sublimate. The proof of this is, that if, as Mr. Beaumé has done, common salt be dissolved in water, and if into this solution some of the *lixivium* of soda be poured, till no more earth be precipitated, in which operation the salt with earthy basis is evidently decomposed, and is changed into a salt with basis of fixed alkali; and if the pure salt remaining in the liquor be afterwards crystallized, and mixed with mercury, and the sublimation be attempted, not a particle of saline sublimate of mercury will be obtained. This experiment has been verified most scrupulously by Mr. Beaumé. Mercury singly cannot decompose common salt, therefore none of the consequences inferred from the inaccurate experiment of Lemery are justly deducible. We might draw other consequences not very favourable to the chemist alluded to, but we abstain from them on account of his personal merit, and that we may not imitate the harsh and satirical criticisms which dishonour his writings.

The sublimate composed of mercury and marine acid, in which the metallic substance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of a precise and determinate proportion of these two substances. Accordingly corrosive sublimate, when well made, that is, as corrosive as it can be, being sublimed a second time with new marine acid, does not unite with a larger quantity of acid, nor become more corrosive. But we do not yet seem to have determined precisely the proportion of marine acid, relatively to that of mercury, in the most corrosive sublimate. According to Lemery, sixteen ounces of mercury produce nineteen ounces of corrosive sublimate; and, according to Takenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furnish 360

pounds of sublimate; which would seem to prove, that the quantity of marine acid is greater in the sublimate mentioned by Takenius than in that by Lemery. But as more of the mercury may be dissipated when the quantity operated upon is but small, than when it is large, we can ascertain nothing from comparing together the results of these two authors. However, we see that the quantity of mercury is much larger than that of the acid, since even in the sublimate of Takenius, the quantity of mercury was more than three times the quantity of acid; which deserves to be remarked, as we shall see when we mention the principal properties of corrosive sublimate.

The specific gravity of this mercurial salt has not been hitherto determined, but it is evidently very considerable. It is very crystallizable, either by the usual method for crystallizing salts, or by sublimation, and the form of its crystals is the same in both cases. It is not deliquescent, is difficultly wetted by water, and, in this respect, is similar to arsenic. It is one of the salts which are very little soluble in water. According to the experiments of Mr. Spielman, an ounce of distilled water can dissolve only thirty grains of it, with the assistance of a heat of fifty degrees of Fahrenheit's thermometer, which corresponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can dissolve only a nineteenth part of its weight of corrosive sublimate.

All these properties of corrosive sublimate are naturally deducible from the large quantity of mercury which enters its composition; it perfectly resembles in this respect all the neutral salts, which contain a matter that is not saline, intimately joined to the saline principle. But this circumstance is very remarkable, that corrosive sublimate has at the same time very contrary properties, by which it also resembles those neutral salts in which the acid is but little connected and imperfectly saturated with their basis. These properties are, 1. Its corrosive quality, which renders it one of the most violent and active poisons; and, 2. Its capacity of receiving a much larger proportion of mercury, which unites intimately with its acid, saturates it entirely, and even so completely, that this salt, from being very corrosive, is rendered, by this new addition of mercury, a sweet sublimate, almost insipid, almost unsoluble in water, and which has nothing in common with a neutral salt but external appearance.

These latter properties of corrosive sublimate do not allow us to doubt that marine acid, although already united in this salt with a large quantity of mercury, and even very intimately, is yet very far from being saturated. Accordingly this acid is, at the same time, in two states in some measure contrary. Several of the properties of corrosive sublimate seem to shew that its acid is saturated as completely as the acid of the most perfect neutral salts; while other properties indicate that it is far from being completely saturated.

To form a just idea of this singular state of marine acid in corrosive sublimate, we must first of all observe, that we should judge very erroneously of the state of the acid of a neutral salt, if we considered the properties of this salt as depending only on its acid. We have elsewhere observed, and we shall prove it further in this article, that bodies which are not saline, being united to acids in neutral salts, have their peculiar action as well as these acids; and that the properties of these salts are always the result of the combined properties of their acids and of their bases.



In the second place, we ought to recollect the distinction we have made under the article SATURATION, into *relative saturation*, and *absolute saturation*, which are two things very different; because, in fact, it happens in many combinations, that a principle is in a relative, perfect saturation, with regard to another; that is, that it is united with all the quantity of this second principle which it can dissolve, although it be very far from being in a state of absolute saturation; that is, from having so exhausted all its action upon this second principle, that no more remains to be exercised upon any other substance: For, if this were not so, we could not make any decomposition by an intermediate substance. Thus in bodies compounded of two principles, such as, for instance, neutral salts, one of their principles, and not the other, may be relatively saturated. Also one of the two principles, or both, may be in a perfect, relative saturation, although one or both be far from absolute saturation.

These things being premised, if we reflect on the properties of corrosive sublimate, we shall easily perceive, 1. That the marine acid cannot be united with so large a quantity of mercury as it is in this salt, without being considerably approximated to a state of absolute saturation; hence corrosive sublimate does not redden blue colors, has no acid taste, does not attract the moisture of the air, is very crystallizable, and not very soluble in water; in a word, that it is nearly in the same state as several neutral salts, as vitriolated tartar and others, the acids of which are generally considered as being well saturated.

Secondly, We shall easily discover also, that although the acid of corrosive sublimate approaches as much to absolute saturation as the above-mentioned properties indicate, it is not nearly in a state of relative saturation with regard to the mercury; since we know that it is capable of uniting again with a much larger quantity of mercury than is in corrosive sublimate, as is shewn by the transformation of corrosive sublimate into sweet mercury; and we shall naturally conclude from these facts, that marine acid is capable of uniting with so large a quantity of mercury, that it cannot be entirely saturated with that substance, without exhausting almost all the action it is capable of, and approaching nearly to the state of absolute saturation. Accordingly we see, that the properties of this acid become insensible, and are almost annihilated in sweet mercury.

Thirdly, in reasoning still from principles above-mentioned, and in applying them to corrosive sublimate, it will evidently appear, that although the acid of this salt is not nearly saturated with mercury, as we have observed, the mercury is nevertheless in a state of relative saturation, with regard to the acid; since, according to Mr. Rouelle's experiment, this salt cannot by any means receive a larger quantity of acid. But if, on the other side, we attend to the quantity of mercury in corrosive sublimate, it will appear very probable, that although this mercury be saturated with acid as much as it can be, and that in this respect it be in a state of perfect relative saturation, yet it is very far from having exhausted upon this acid all the tendency it has to combination in general, and from being in a state of perfect, absolute saturation. In fact, on one side, the aggregation of the mercury is broken in corrosive sublimate, and consequently all its integrant parts are capable of exerting their general tendency to combination: but, on the other side, these parts of mercury are united but to a very small quantity of acid, and probably much of their tendency to union remains

therefore unsatisfied; and we may reasonably conjecture, that from this condition, or state of the mercury in corrosive sublimate, proceeds the causticity of that saline matter.

This notion will undoubtedly appear very bold to those who are accustomed to consider the causticity of saline matters as an effect only of the concentration and imperfect saturation of their saline principles.

But we repeat it, that we should judge very erroneously of the properties of any compound body, if we were to attribute them to one of its principles only. On the contrary, all the phenomena of chemistry shew, that all the constituent parts of any compound contribute more or less to all the properties of this compound. All the parts of matter are active, by the general tendency which they have to mutual combination. Nothing is purely passive in nature; and if certain substances seem to us to be inactive and inert, it is because their parts, having exhausted all their tendency and activity one upon another, by their union, are in a seeming rest, which we call saturation, and do really become inactive with regard to many other bodies: but when by some cause this union is broken, and its parts become disengaged, their essential activity then appears again in all its force, they resume all their tendency to combination, they are in a violent state, till they find some substance with which they may unite, and satisfy this tendency. This violent state, this *visus*, are the same thing as causticity, or rather this latter quality is an effect of the former qualities rendered sensible by their exertion upon animated bodies. Accordingly, all matter in nature, however inactive and passive it may seem, is capable of becoming, by the separation of its primary integrant molecules, an agent or solvent, and a very powerful corrosive.

We conceive then, that in corrosive sublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one side, in this violent state, in this tendency to union above-mentioned; and, on the other side, that as this tendency to union is only capable of being satisfied partly, and imperfectly, by the marine acid, much of it remains unsatisfied, which gives a proportionable degree of causticity to these molecules; so that the mercury itself of the corrosive sublimate is corrosive, and probably much more so than even the marine acid.

However strange and singular this opinion may appear, we shall find, by reflecting on the nature of corrosive sublimate, that no other cause of its causticity can be conceived. In fact, we must allow that this salt is much more caustic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be swallowed without the least inconvenience; whereas half the quantity of corrosive sublimate, diluted in the same or a much larger quantity of water, would infallibly poison. If then we suppose that the causticity of this salt is nothing else than the causticity of the marine acid contained in it, how can we conceive that this acid, which, very far from being disengaged, and from possessing all its acidity in corrosive sublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutralised so as to form a very crystallizable salt, not deliquescent, and not very soluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corrosive than the same acid when free and disengaged? We might as well say, that vitriolic acid is  
more

more corrosive in vitriolated tartar than when pure. The causticity then of corrosive sublimate must be chiefly attributed to the mercury, which is the predominant and least saturated part of that saline substance. The mercury in corrosive sublimate appears to be nearly in a similar state as the earthy principle in fixed alkalis; that is to say, its aggregation is destroyed, at least in great measure, and its quantity is very large in proportion to that of the saline principle. Accordingly, corrosive sublimate, instead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the observations of Mr. Rouelle; and in the same manner as alkalis seem to owe their causticity to the proportion and peculiar state of their earth, so also does the causticity of corrosive sublimate proceed from the quantity and disposition of its mercury. This causticity then is rather of an alkaline than of an acid kind.

An objection might be made here, that if the causticity of corrosive sublimate depended on the mercury, it ought to be increased by increasing the proportion of the mercury; whereas we know, that the addition of more mercury has a contrary effect, as we find from the instance of sweet mercury.

The answer to this objection is not difficult. Although the causticity of corrosive sublimate depends more on its mercury than on its acid, we cannot doubt that this acid also contributes to produce this effect, according to the general rule, that all the principles of bodies conduce more or less to their properties: but the acid of sublimate is indeed nearly in the state of absolute saturation, although it is not quite in that state; and however neutralised it may seem, it is yet capable of a certain degree of action: but when it is totally saturated with mercury, it is then also completely in a state of absolute saturation; because this acid is capable of uniting with so much mercury, that when it is combined with this metallic substance, its relative saturation and its absolute saturation are almost the same thing. We need not then be surprized, that in this respect, the causticity of the sublimate is considerably diminished; but, besides, when the quantity of mercury much exceeds what ought to be contained in corrosive sublimate, we may easily perceive that the parts of the mercury, being pressed nearer the parts of the acid, are also more and more united together, and approach more nearly to the state of aggregation; in which state mercury cannot have any causticity. *See for the properties, chemical and medicinal, of corrosive sublimate, the articles ACID (MARINE), and MERCURY.*

DCLXIX. S U B L I M A T E (S W E E T). *See MERCURY (SWEET).*

DCLXX. S U B L I M A T E (R E D). If a solution of mercury in nitrous acid be evaporated and dried, and then exposed to a strong heat in a matrafs, the nitrous acid will be separated from the mercury in great measure, and will be dissipated in red vapors; the saline mass remaining in the matrafs acquires at first a yellow color, which afterwards changes to an orange color, and lastly to a red. This is called *red precipitate*. But by exposing this red matter to greater heat, it is sublimed; while its color is preserved. It is then called *red sublimate*. This sublimate is not used.

DCLXXI. S U G A R. Sugar is a crystallizable essential salt, of a sweet agreeable taste, contained, more or less plentifully, in many kinds of vegetables;

vegetables; but in most of them is so small a quantity, or confounded with so much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains the greatest quantity of this essential salt is a kind of reed, which grows in hot climates, called *Arundo donax*.

The method used for the extraction of sugar from the cane is the same as is employed for the extraction of any essential salt from the juice of plants, with this difference, that as sugar and liquor containing it are very fermentable, this salt is not obtained by a regular crystallization, but by a much speedier coagulation.

After having entirely expressed the juice from sugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of ashes, both to clarify it, and to evaporate it so much, that when it cools, most of it coagulates or confusedly crystallizes. This coagulated matter is to be separated from the remaining liquor, which is called *melasses*. From this liquor, by fermentation and distillation, an ardent spirit is obtained, called *rum*. The solid substance, or sugar, is mixed with much mucilaginous extractive matter, which renders it soft and red. To purify, or, as it is called, to *refine* it further, it must be redissolved in pure water, and its heterogeneous parts must be separated by boiling with quicklime and lixivium of ashes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Lastly, the sugar, when refined, is put into earthen conical vessels open at both ends, the smaller of which is turned downwards. The sugar is covered with some earth moistened with water. This water filtrates through the sugar, dissolves the mucilage or slime which still adheres to the sugar, and flows out at the opening in the lower point of the conical vessel. In this manner is obtained this pleasant and useful salt. To whiten and purify it perfectly many clarifications are required; the cause of which is chiefly a slimy matter, like honey, that adheres to it.

This essential salt is soluble in water, like all other salts, and even is one of those salts that is soluble in the smallest quantity of water.

It is crystallizable; and its crystals, when slowly and regularly formed, are beautiful and transparent, called *sugar-candy*. This salt consists of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of sweet and not volatile oil, which is in a state perfectly saponaceous, that is, entirely soluble in water by means of the acid.

Sugar, when distilled, yields a phlegm, an oily empyreumatic acid, a small portion of colored empyreumatic oil, and leaves a considerable quantity of residuous coal.

This salt is very susceptible of the spiritous fermentation, when it is diluted in a sufficient quantity of water; and, like all the other substances capable of that fermentation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables have not been sufficiently examined, to enable us to determine, whether they be perfectly of a saccharine nature. We know, however, that they furnish by analysis the same principles, and nearly in the same proportion; that they all have a sweet, agreeable, and generally saccharine taste; that every vegetable or animal substance that is saccharine is also nutritive and fermentative; and, lastly, that genuine sugar may be obtained from most of them.

Mr.

Mr. Margraaf has obtained sugar from the roots of several plants, as from carrots, parsnips, white and red beets. Some of these roots, as, for example, the white beet, furnished a very considerable quantity of sugar. He obtained about half an ounce of sugar from half a pound of the dried root. This able chemist, considering that sugar is soluble in spirit of wine, and that the mucilaginous parts of plants are not soluble in that fluid, easily obtained a pure sugar by digesting the dried roots in that spirit, and by evaporating the liquor. Afterwards, hoping to find a cheaper method, that his discovery might be useful, he attempted successfully to obtain sugar by the ordinary process very little varied. He could not indeed obtain a very pure sugar without repeating very frequently the solutions, clarifications, and other operations, as may be seen in his Memoir, or in the eighth Dissertation of his *Opusculs Chimiques*. But at last he did succeed; and we have reason to hope, that by improving the process, much sugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from several trees, as the sycamore, and the birch trees, some of which have more of a saccharine taste than several of the plants from which Mr. Margraaf extracted sugar.

The chief, and perhaps the only difficulty to be surmounted in this extraction of sugar proceeds from the viscid matters, which are so mixed and blended with the saccharine substance of plants, that they prevent its crystallization. The saccharine and mucilaginous parts might be separated from each other by means of a menstruum, which could dissolve the sugar and not the slimy substance, or which could dissolve the latter and not the former. To discover such a menstruum seems to be the proper object of inquiry for those who would prosecute this subject.

DCLXXII. SUGAR of LEAD. See SALT of LEAD.

DCLXXIII. SUGAR of MILK. See MILK.

DCLXXIV. SULPHUR. No word has been so much used by chemists, and at the same time so much abused, as *sulphur*. By this the ancient chemists denoted all inflammable substances of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They spoke continually of the sulphurs of metals, of the sulphurs of plants, of the sulphurs of animals: oils, ardent spirits, resins, bitumens, were all sulphurs. In every thing they found a sulphur. Even now, alchemists and others who have only confused ideas of chemistry, from reading old chemical books, talk incessantly and decisively of sulphurs.

To Becher, and still more to the illustrious Stahl, we owe the simple, clear, and precise ideas which we now have of the several kinds of inflammable substances, formerly confounded under the general name of sulphur. By the sagacious distinction they have made between the pure and simple inflammable principle, and the more compounded bodies which contain it, and owe their inflammability to it, we acquire a knowledge of the true theory of sulphur and of all inflammable substances.

Since Stahl has unfolded this sublime theory, we know that the inflammable principle is identical, always alike, and the same in every body; that this principle by its combination with different substances produces all the inflammable matters which we know. Oils, fats, resins, bitumens, ardent spirits, coals, metals, sulphur properly so called, or common sulphur, are so many

compounds, all which have the common property of burning, because they all contain the principle of inflammability, but which differ in other respects, because this principle is united to different substances, and in different proportions.

Stahl has established these important truths, chiefly by examining, by decomposing, and by re-composing common sulphur, and by demonstrating from the most satisfactory experiments, that this sulphur consists of vitriolic acid united with the purest and simplest inflammable principle. We shall relate as shortly as we can the results of his researches upon this subject.

Nature probably forms, and combines daily, mineral sulphur within the earth. This substance is abundantly diffused in many places, especially where metallic minerals exist. Sulphur almost pure, called *native sulphur*, is found in volcanos and in grottos, where it is sublimed in form of transparent crystals. But the greatest quantity of sulphur which exists naturally is combined with metals in ores and especially in pyrites. As sulphur is fusible and volatile, it is procured from these minerals by distillation and sublimation. See *SMELTING of ORES*.

Sulphur, such as it is in commerce and in arts, is of a pale yellow or citron color, of a disagreeable and peculiar smell, which is rendered more sensible when the sulphur is heated or rubbed. On rubbing, sulphur is electrified. Its specific gravity is much greater than that of water, and less than that of earths and stones. It is brittle and pulverable; altho' it may also be easily softened, as we shall afterwards observe.

Sulphur seems to be incapable of receiving any alteration from air or from water, separately or conjointly, nor even from fire in close vessels. Sulphur, exposed to heat in a subliming vessel, is melted with a very gentle heat, and then is sublimed, and adheres to the capital, forming small very fine needle-like crystals, called *flowers of sulphur*. This sublimed sulphur is essentially the same as that which has been only melted; and it may be thus sublimed many times without alteration. If sulphur, which has been exposed to no more heat than sufficient to melt it, be cooled very gradually, it crystallizes in form of many needles crossing each other. Some of these pointed crystals may also be observed in the interior parts of the lumps of sulphur which have been melted and cast into cylindrical moulds as they are commonly sold; because the center of these cylindrical rolls is more slowly cooled than the surface. Sulphur also gives this needle-like form to cambrar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by exposure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combustion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always blueish, not very luminous, and not accompanied with any foot or smoke, but with an acid vapor of a penetrating and suffocating smell. This vapor, confined by means of a glass bell, and received into the vapor of water, introduced for that purpose into the same bell, is called *spirit of sulphur*, which we shall afterwards shew is the vitriolic acid, that is at first volatile and sulphureous, from the small quantity of inflammable principle that it still retains, but which afterwards becomes pure vitriolic acid.

If, on the contrary, sulphur is burnt in open air but very slowly, its flame is so little luminous, that it can be perceived only in the dark, like a small bluish glimmering light; and so little ardent, that it cannot kindle the most inflammable substances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the sulphur that is contained in gun-powder without kindling the powder. When this experiment is made, a tile must be equally heated and to a certain degree, that is, a little more than is requisite for the success of the experiment. Upon this tile, thus heated, some grains of gun-powder are thrown, to discover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is usual. More powder is thrown on the tile, till this be so much cooled, that the powder does not fulminate, but only emits a white smoke. If the tile and powder be carried in this state to a dark place, the vapor, which seemed to be a white smoke, will then appear to be a true flame, but very bluish and faint; which will continue till all the sulphur of the powder be consumed, if the tile remains sufficiently hot for that purpose.

We may easily perceive, that when the sulphur burns thus weakly and slowly, a part of its inflammable principle is dissipated without inflammation, and that consequently the acid which is disengaged by that combustion, ought to be more volatile, penetrating, and sulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile sulphureous acid by burning sulphur, as for the whitening of stuffs by the vapor of sulphur, it must be burnt very slowly, as Stahl has well remarked.

As nothing remains after the burning of sulphur, unless some extraneous body happens to be mixed with it; and as, during this combustion, nothing is perceptible but two matters, one of which is destroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that sulphur is composed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this substance will render our knowledge of its nature and its principles more complete and accurate.

Sulphur heated so much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered solid, but in this experiment it acquires a considerable degree of softness, which indeed only lasts a certain time; after which the sulphur recovers its natural consistence and brittleness.

Pure acids seem to have no action upon sulphur, especially in the humid way. But Mr. Beaumé has observed that if concentrated vitriolic acid be poured upon sulphur, and heated to a certain degree, this sulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which seems to shew some action of the acid upon the sulphur. But this sulphur is not in any other respect changed.

Alkalis fixed and volatile, and even calcareous earths, dissolve sulphur, render it more or less soluble in water, and form with it compounds called *livers of sulphur*. The sulphur may be separated and precipitated, by means of an acid, from these substances; in which case, it appears as before, only much divided.

This experiment shews that sulphur is not decomposed by uniting with alkalis. Nevertheless the strong fetid smell of liver of sulphur, and the fa-

cility of decomposing sulphur while it is thus united with an alkali, shew that, in this combination, the connexion of its parts are weaker than when it is uncombined. See LIVER of SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decomposed by the combustion of this principle. But in this detonation we perceive only the two principles of sulphur above-mentioned. Its phlogiston, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the sulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *sal polybreft of Glaſer*. This is completely proved in the experiment of the *clyſſus of ſulphur*. See CLYSSUS.

Sulphur unites eaſily with all metallic matters, excepting gold, platina, and zinc; at leaſt we have not found the means of uniting it with theſe, directly, and without ſome intermediate ſubſtance. The degrees of affinity with which ſulphur combines with thoſe metals to which it may be readily united, are different; for it not only unites more eaſily and abundantly with ſome than with others, but it alſo quits thoſe with which it has a leſs affinity, to unite with others to which it has a ſtronger affinity.

The affinities of ſulphur according to Mr. Geoffroy's table are, fixed alkali, iron, copper, lead, ſilver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's table, they are, iron, copper, tin, lead, ſilver, biſmuth, regulus of antimony, mercury, aſenic, and cobalt: gold and zinc are marked in this table as being incapable of uniting with ſulphur.

The compounds formed by ſulphur with different metals are different; but all of them poſſeſs a metallic luſtre, without any ductility: theſe combinations of ſulphur and of metals are very frequently found in a natural ſtate. Almoſt all the metals which we dig from the earth are naturally found combined with ſulphur, forming moſt of the ores and metallic minerals.

The properties of the combinations of ſulphur with metallic matters have been little examined, becauſe theſe combinations are not of any uſe; but, on the contrary, when they are found, they muſt be decompoſed, that the metals may be obtained ſeparately from the ſulphur. Nevertheleſs, we know not only that metals have different degrees of affinity with ſulphur; in conſequence of which property, ſulphur may be and actually is, in many metallurgical operations, ſeparated from ſome metals by means of others, to which it is more diſpoſed to unite; but we alſo know that ſulphur facilitates the fuſion of hard and difficultly fuſible metals, ſuch as copper and iron; and that, on the contrary, it renders the ſoft and fuſible metals, as tin and lead, leſs eaſily fuſible. Theſe ſingular effects ſeem to proceed from the difference of the affinity of ſulphur to the ſeveral metals.

Sulphur may be ſeparated from metallic matters by ſeveral methods. Firſt, as ſulphur is volatile, and as theſe metallic matters are fixed, or at leaſt leſs volatile than ſulphur, the mere action of fire is ſufficient to ſeparate ſulphur from moſt metals. As this method is ſimple, and not expensive, it is generally employed to ſeparate ſulphur from ores; which effect is produced by the *torrefaction* or *roaſting* of theſe ores. We muſt, however, except the ore of mercury, or native cinnabar, and alſo the combinations of aſenic with ſulphur, which cannot be decompoſed without an intermediate ſubſtance, from the great volatility of mercury and of aſenic: although perhaps it would not be im-  
poſſible



possible to separate the sulphur from these compounds, without an intermediate substance, by a heat carefully applied, long continued, and with access of air.

Secondly, several combinations of sulphur with metals may be decomposed by means of acids, which dissolve the metallic matter, without attacking the sulphur. But in several of these compounds, the sulphur defends the metal from the action of the acids; and this separation by acids does frequently not succeed, or succeeds only imperfectly. Crude antimony is one of the sulphurated metallic substances from which sulphur may most easily be separated by means of aqua regia. This menstruum seizes readily the regulus of antimony contained in mineral antimony, and separates from it the sulphur, which then appears in form of a white powder.

Lastly, we may, as we have already said, separate several metals from sulphur by means of other metals, to which the sulphur has a greater affinity. This separation is practised in several operations, as in the *dry parting*, the *purification of gold by antimony*, the *decomposition of cinnabar*, of *orpiment*, and of *crude antimony*. See the articles ESSAY of ORES; ORES; PYRITES; SMELTING of ORES; and all the articles of the several metals and semi-metals:

Oils and oily matters, of whatever nature, are all capable of acting upon sulphur, and of dissolving it. Several solutions of sulphur in essential oils are used in pharmacy, which have been named from the oils employed; as *terebinthinated balsam of sulphur*, and *anisated balsam of sulphur*; and other solutions have been made of sulphur in expressed sweet oils, as that in the oil of nuts, called *Rulland's balsam of sulphur*.

Sulphur cannot be dissolved in oils, according to Mr. Beaumé, without a heat sufficient to melt it. A larger quantity of sulphur is kept dissolved in the oil while hot than when cold; and accordingly when oil has been saturated with sulphur by means of heat, a part of the sulphur separates from it when it cools, in the same manner as many salts kept dissolved in hot water are crystallized when the water becomes cold. The analogy betwixt the salts and sulphur in these instances is also observable in this respect, that when the oil in which the sulphur is dissolved is very gradually cooled, the sulphur crystallizes regularly, as salts do in similar circumstances.

Sulphur is not decomposed by the union which it contracts with oils, when no more heat is applied than is necessary for the solution. For the sulphur, when separated from the oil, is found to be possessed of all its properties. It appears, however, that the connexion of its principles is in some measure altered by this combination; at least, if we may judge from the color and smell of the balsams of sulphur which are different from those of the sulphur, or of the oil.

But when the balsams of sulphur are distilled with a heat capable of entirely decomposing them, the sulphur itself is then also decomposed. For according to an experiment made by Homberg, and some other chemists, the same principles are obtained by this distillation continued till the matter in the retort be dry, as are obtained from a combination of pure vitriolic acid with oils. These principles are, first, a portion of oil, when the oil of which the distilled balsam is composed was an essential oil; then some volatile sulphureous acid, which is at first watery, and afterwards becomes stronger; along with this acid more oil

rises, which becomes more and more thick towards the end of the distillation; and lastly, when the retort has been red-hot, nothing remains but a fixed coal.

From the above-mentioned products we find, that the sulphur and part of the oil are decomposed in this distillation. The vitriolic or sulphureous acid certainly proceeds from the sulphur: for no quantity of that acid can be obtained from any kind of oil, nor from any pure vegetable or animal oily matter. The water contained in this sulphureous acid is evidently a part of the water, which is a principle of the oil: for the vitriolic acid of the sulphur being in a state perfectly concentrated and dry, as shall be afterwards shewn, could not otherwise contain so much water as it does in this operation. Lastly, the coal which remains after the operation is a portion of the earth that is a principle of the oil, intimately united with some of the inflammable principle either of the oil or of the sulphur, or most probably of both.

In this mutual decomposition of sulphur and oil, the concentrated acid of the sulphur seems to attack the watery principle of the oil, while its phlogiston, which by this new union loses much of its adhesive power, is partly disengaged, and confounded with the phlogiston of the oil. Thus the sulphur is changed into volatile sulphureous acid. And probably also a certain quantity of inflammable principle is disengaged in this experiment, and is dissipated in vapors. Such appear to be the phlogistic vapors, which, kindling at once, produce the terrible explosions that sometimes happen when the combinations of oil and of sulphur are carelessly heated. Hossman relates a singular instance of an explosion of this kind, which happened in a laboratory, where balsam of sulphur had been left in a matrafs upon the fire.

Spirit of wine does not act sensibly upon sulphur, unless these two substances be applied to each other in the state of vapor, as the Count de Lauraguais discovered. Many combinations, now believed to be impossible, might be effected by employing the most powerful means in chemistry; namely, an extreme division and separation of integrant parts, as the Count de Lauraguais has done in the abovementioned fine experiment. By this means, chiefly, we may arrive at great discoveries. From the above-mentioned properties of sulphur we learn, that this substance is composed of vitriolic acid and phlogiston. Stahl demonstrated this important truth so clearly and completely, as to shew the true state, and even the proportion of the principles of sulphur, not only from its analysis, but also by its artificial composition, of which we shall now speak.

The process by which this chemist made sulphur exactly similar to native sulphur, consists in mixing and melting together in a crucible equal parts of fixed alkali and of vitriolated tartar, to which is added a quantity of powdered charcoal equal to a fourth part of the weight of the salts. The matter is to be stirred with an iron rod, that the charcoal may be well mixed with the salts; the crucible is to be covered; and a pretty strong heat is to be suddenly applied, and continued during a very short time. The crucible is then to be removed from the fire, and the melted matter is to be poured upon a stone previously greased. This matter, which sparkles when it is poured, is coagulated by cold, and becomes a brittle mass, of a deeper red color than ordinary liver of sulphur; but it has the smell, the solubility, the deliquescency,

deliquescency, and all the other properties of liver of sulphur. By dissolving it in water, and by adding any acid to the solution, an artificial sulphur will be precipitated, which being collected and dried, is found not to differ from natural sulphur.

The color of this dry liver of sulphur is redder than that of the ordinary preparation of that name; and when dissolved in water, its solution is of a deep green color, in which respect also it differs from the ordinary liver of sulphur. These differences proceed from some foreign matter united with the liver of artificial sulphur; and this foreign matter is a part of the charcoal employed in the process for making the sulphur. For the whole quantity of charcoal added not being converted into sulphur in this process, some part of it is dissolved by the liver of sulphur, as soon as this is formed; charcoal being soluble in liver of sulphur; as the younger Mr. Rouelle has shewn.

We should be much mistaken if we believed, that the sulphur obtained in this operation existed ready formed in any of the substances employed, and that it is only extracted from these. Glauber had, before Stahl, performed this operation, by employing his *sal mirabile* instead of vitriolated tartar; but from his ignorance of the true theory, he fell into this mistaken opinion. Boyle also, having procured sulphur by distilling to dryness a mixture of vitriolic acid and oil of turpentine, did not believe that he had produced this sulphur, but only that he had separated it from the substances employed. On the contrary, we know certainly from many proofs, that not a particle of sulphur exists in vitriolic acid, nor in neutral vitriolic salts with basis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and consequently the sulphur obtained in these operations is a new product, resulting from the union of the vitriolic acid with the inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with the vitriolated tartar in this process is not absolutely necessary; for sulphur may be produced merely from any vitriolic salt with any inflammable matter, made red-hot together: but the alkali is useful in this process, by facilitating the fusion of the vitriolated tartar, and by preventing the dissipation and combustion of most of the sulphur, as soon as it is formed. This alkali unites with this sulphur, and forms a liver, in which the sulphur is less disposed to burn, and be dissipated, than when it is not engaged with any fixed and incombustible body.

Although, rigorously speaking, the vitriolic acid itself, when disengaged, and treated properly with any combustible body, can always produce sulphur; nevertheless, in this operation, an acid engaged in some basis to which it adheres strongly ought always to be employed; such is the acid in vitriolated tartar, in Glauber's salt, and even in almost all neutral vitriolic salts with earthy and metallic bases; because vitriolic acid cannot contract with the inflammable principle the intimate union which is requisite for the production of true sulphur, excepting it be deprived of all the water that is not necessary to its saline essence; that is to say, in its highest degree of concentration, and even in a dry state. Besides, if a red heat be not absolutely necessary to effect this combination, as the sulphur formed in the solution of some metallic matters by vitriolic acid shews, it

Nevertheless very useful. But when a disengaged vitriolic acid is employed; as, for instance, when a mixture of this acid with an oil is distilled; the greatest part of the acid is converted into volatile sulphureous acid, while any moisture remains in the mixture, and the sulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogiston of the earthy coal of the oil, forms the sulphur.

Hence, sulphur may be more copiously and quickly made by applying to a coal vitriolic acid engaged in some basis, which renders it so fixed that it may, by fire, be deprived of all superfluous water, and even be made red-hot, than by employing this acid in any other manner. Accordingly Stahl's process is the best. These considerations on the best method of making sulphur are of little value, because natural sulphur is plentiful and cheap. But the discovery that sulphur can be thus made, and the theory which Stahl has given concerning this subject, are very important. For from thence we not only learn the nature of sulphur, of which we had an imperfect, and even false, idea; but, what is much more valuable, we may thence draw a number of very important and very general inferences, the chief of which we shall now mention.

First, vitriolic acid and the inflammable principle cannot form sulphur by combining together, unless they both be deprived of all moisture, and be perfectly dry. Hence no inflammable body which contains in its composition water, such as oils and ardent spirits, can form with this acid, sulphur, but only a volatile sulphureous acid, till these inflammable matters be decomposed, and reduced to a state of coal, which is one of the dry combinations of the inflammable principle.

Secondly, the inflammable principle of all combustible bodies is always capable of forming sulphur with the vitriolic acid, provided it be, or can be made, dry. Thus ardent spirits, oils, and oily matters; or rather the coals of all these substances, and all combustible metals, do always form sulphur when treated properly with vitriolic acid; and whatever the nature of the combustible body be which transfers the phlogiston to the acid, the sulphur resulting from it is always the same, and always perfectly similar to natural sulphur. Hence an important proposition is inferred, that only one inflammable principle exists, which is always the same, whether it resides in resins, in bitumens, in oils and fat, in coals, or in metals. For if the inflammable principle of all these combustible bodies was not the same principle, these bodies might form different sulphurs with vitriolic acid, which we find from experience they cannot do.

Thirdly, vitriolic acid always quits any body with which it happens to be combined, when it can unite with the inflammable principle of any other body, and with this principle forms sulphur when it is properly applied. Hence, this acid has a greater affinity with the inflammable principle than with any other substance; and hence we may discover, by means of phlogiston, the vitriolic acid, with whatever substances it may be combined; and reciprocally we may, by means of vitriolic acid, discover the inflammable principle in all bodies in which it exists in a combustible state.

Fourthly, the principles and properties of sulphur being known, we may deduce from these properties a more accurate knowledge of the particular nature of

of the inflammable principle, by comparing the differences between sulphur, volatile sulphureous acid, and pure vitriolic acid. From this comparison we find that the smell and color of sulphur, its volatility, its constant dryness, its unsolubility in water, which properties do not belong to vitriolic acid, are produced by the inflammable principle, that possesses all these qualities in itself, or that is, at least, capable of communicating them to the compounds in the combination of which it enters. See the Article PHLOGISTON.

Fifthly, we have reason to believe that the inflammable principle possesses eminently the abovementioned properties; for we know that the quantity of it in sulphur is much less than the quantity of the vitriolic acid. Stahl has made a fine experiment to discover nearly the proportion of the two principles of sulphur. This experiment consists in putting a quantity of powdered liver of sulphur upon an earthen-ware plate, and placing this plate upon a fire so gentle that the liver of sulphur shall not be melted, nor even so softened that it can run into lumps. This powder must be stirred, and the fire must be increased towards the end, till no smell be perceived. The remaining matter is to be dissolved in water, and by crystallization a very pure vitriolated tartar is formed.

In this operation, the inflammable principle of the sulphur is gradually dissipated without any sensible combustion, and its acid combines, or remains combined, with the alkali of the liver of sulphur. But we must observe, that to render this experiment exact, and to draw from it accurate conclusions, the following conditions are required: 1st, we must know precisely the quantity of sulphur contained in the liver of sulphur employed; 2dly, the liver ought to contain rather too much than too little fixed alkali, that there may be certainly enough of it to saturate all the acid of the sulphur; lastly, no part of the sulphureous acid must escape during this decomposition; and therefore no smell of this acid, but only that of the liver of sulphur, which is very different, ought to be perceived. To prevent this dissipation of volatile acid, we must proceed very slowly; and the operation accordingly requires a long time. Mr. Brandt, who has carefully repeated it, found from the quantity of vitriolated tartar obtained by this method, that, in sulphur, the proportion of inflammable principle is to that of the vitriolic acid as three to fifty; that is, that the sulphur contains only one-fifteenth of its weight of inflammable principle.

Such is the state of our actual knowledge concerning the nature and principles of sulphur, which Stahl has rendered very compleat and accurate. We find that sulphur is a peculiar combination of the purest inflammable principle with vitriolic acid; that not a particle of oil is contained in it; that it is therefore very different from bitumens, with which it has been long confounded; that, still more improperly, the name of sulphur has been given to all other inflammable bodies, which are entirely different from it; that we ought therefore to confine the name of sulphur to the compound formed of pure vitriolic acid and pure phlogiston, unless we would apply it, as the ancient chemists have done, to the inflammable principle itself, which they called the *principal sulphur*; but in this case we ought to give another name to mineral sulphur.

Let us remark, nevertheless, on the subject of the name *sulphur*, that as other acids besides the vitriolic can also contract an intimate union, and form compounds with pure phlogiston, this name may be generally applied to all compounds

compounds of pure acid and phlogiston, which may be distinguished from each other by adding the name of the acid; as *vitriolic sulphur*, *nitrous sulphur*, and *marine sulphur*, if any such sulphur does exist: but let us also remark upon this subject, that we can give this name of *sulphur* to those compounds only which do not contain any oil; this condition being essential to the sulphureous combination; and consequently, that we cannot admit of *acetous sulphur*, of *tartareous sulphur*, or of others of this nature containing vegetable acids, which cannot ever form a truly sulphureous combination, on account of the oil which enters into their composition as an essential principle. See the articles ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), DETONATION of NITRE, LIVER of SULPHUR, and PHLOGISTON.

The uses of sulphur are considerably extensive in chemistry, in medicine, and in arts. The liver of sulphur is employed in chemistry for several solutions, which may be seen at the article LIVER of SULPHUR. Sulphur is also useful for several fusions, precipitations, and separations of metals and minerals, as we have already mentioned. Lastly, as sulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practised, of extracting from it this acid, by burning sulphur in close vessels with the addition of some nitre, and by an operation similar to that of the clystus. See CLYSTUS.

Sulphur is employed in medicine, both internally and externally, for asthmatic diseases of the breast, and for several diseases of the skin of the nature of the itch. The internal preparations of sulphur are, flowers of sulphur, washed sulphur, magistery of sulphur, tablets, balsams, livers of sulphur, and others, in some of which this substance is not altered, but only purified and divided, and in others, is combined and associated with other substances; without reckoning the sulphureous combinations of antimony and of mercury.

Some physicians and chemists, considering that sulphur is insoluble in water, and capable of resisting the action of most menstrua, have advanced that it can produce no effect when taken internally, single and unaltered: but this assertion seems to be without foundation; for we are certain that the sweat and perspiration of those who take sulphur internally have a smell evidently sulphureous. Besides, sulphur is much more soluble than is generally believed. It is attacked by all oily and saponaceous substances, and consequently by almost all animal liquors.

We cannot easily form a very distinct and clear idea of the manner in which sulphur acts internally upon our bodies; but from observations made upon its effects, it appears to be dividing, stimulating, and somewhat heating: it principally acts upon the perspirable parts of the body, the chief of which are the skin and lungs; and from this property, it is particularly useful in some diseases of these parts.

Sulphur is also a powerful repellent, as appears from its curing several kinds of itch merely by external application in form of ointments and pomatums.

Several mineral waters, which are drank, or used as baths, for some diseases, owe their good qualities to sulphur contained in them. Such are the waters of Caucerts, of Mont D'or, of Aix-la-Chapelle, and of Saint-Amant. Accordingly, these waters are employed in several diseases of the breast and of the skin.

skin. Lastly, sulphur combined with other substances may contribute to their medicinal powers. *See the articles* BALSAM of SULPHUR, CINNABAR, ETHIOPS MINERAL, MINERAL WATERS, LIVER of SULPHUR, KERMES MINERAL.

Sulphur is also used in several arts. By means of it fine impressions of engraved stones are taken. Matches are formed of it; and its utility as an ingredient in the preparation of gun-powder and fire-works is well known. Lastly, it is used for whitening wool, silk, and many other matters exposed to its vapor during its combustion, the colors and reds of which could not be destroyed by any other substance, but are quickly chased by this acid vapor.

DCCLXXV. SULPHUR (GOLDEN) of ANTIMONY. Golden sulphur of antimony is a mixture of sulphur and regulus of antimony, of an orange color, which is obtained by dissolving the scoria of regulus of antimony, and by precipitating this solution by means of an acid.

We may see at the article REGULUS of ANTIMONY, that this scoria is a liver of sulphur, containing a certain quantity of the reguline part of antimony. When therefore this antimoniated liver of sulphur is dissolved in water, and when any acid is added to this solution, the acid seizes upon the alkali of the liver of sulphur, by means of which the sulphureous and reguline parts of the antimony were kept suspended in the water, and at once precipitates both these.

Although this precipitate be composed of sulphur and regulus of antimony, as crude antimony also is, its properties are nevertheless very different from those of this mineral. The precipitate has no metallic color or appearance, and is besides possessed of a powerful emetic quality, which the antimony has not. These differences proceed from the sulphur of the precipitate not being united with the reguline part in the same manner, nor so intimately, as in crude antimony. In the golden sulphur, the reguline part is only *mixed* with the sulphur, and is in a great measure disengaged and uncombined; whereas in crude antimony, it is intimately connected and united with the sulphur.

Golden sulphur has some resemblance to kermes mineral: but it differs essentially in some circumstances, namely, that a small portion of fixed alkali remains united with the kermes when well prepared, that is, not too much washed, and that the proportion of sulphur is greater in kermes than in the golden sulphur. To be convinced of these differences, we need only to attend to the circumstances which accompany the precipitation of these two substances. Kermes is precipitated spontaneously without addition of any acid, and merely by the cooling of the solution of the antimoniated liver of sulphur which contains it: it is therefore composed of the reguline part, but especially of the superabundant quantity of sulphur, which the alkali cannot keep dissolved, but by means of a heat almost equal to that of boiling water: whereas the solutions of antimoniated liver of sulphur, not only that of kermes itself, but also that of the scoria of the regulus of antimony which has deposited its kermes by cooling, contain no more sulphur than the alkali can keep dissolved without heat, which quantity is therefore less than in the kermes. Besides, the acid necessary for the precipitation of the golden sulphur seizes all the  
alkali;

alkali; whereas a little of it always adheres to the kermes during its precipitation.

The golden sulphur of antimony was much employed when preparations of antimony were first introduced into medicine, but is now pretty much neglected; and justly, because the kermes and emetic tartar produce the same effects more gently and more uniformly. See ANTIMONY and KERMES (MINERAL).



## T.

DCLXXVI. **T** A L K. *See* MICA.

DCLXXVII. **T** A R. *See* PITCH.

DCLXXVIII. **T A R T A R**. Tartar is a concrete, oily, vegetable acid, which is deposited and is crystallized in liquors that have undergone the spirituous fermentation. It is a kind of essential salt of wine.

Probably wines of all kinds deposit a greater or less quantity of tartar; but the wine of grapes is one of those which furnish the most of it, and the tartar of this wine is almost the only one that is employed or known.

All wines of grapes do not furnish an equal quantity of tartar. Some of them deposit it abundantly, and others but a small quantity only. Sometimes a longer and sometimes a shorter time is required for the deposition of tartar. Generally a long time is required, and also an insensible kind of fermentation, which continues in the wine a long time after the signs of the sensible spirituous fermentation have ceased. *See* WINE.

The tartar is deposited on the sides of the casks containing wine. On these a hard crust is formed, which becomes more and more thick; and as a portion of the fine dregs of the wine adheres to this crust, the tartar of white wine is of a greyish-white color, and is called *white tartar*; and that of red wine has a red color, and is called *red tartar*.

Tartar, when separated from the casks on which it is formed, is mixed with much heterogeneous matter, from which it is purified for the purposes of medicine and of chemistry. This purification of tartar is performed at Montpellier, and consists (as we find from a Memoir of M. Pizes, Professor of Medicine at Montpellier, printed amongst the Memoirs of the Academy for the year 1725) in boiling tartar in pure water, in filtrating this water, and in allowing the saline matter to deposit by cold. By this first operation, the grosser impurities which adhere but slightly to the tartar are separated: but the

crystals obtained by this operation are still red, and charged with an oily matter extraneous to the tartar.

From this extraneous matter the tartar is purified by boiling it in water in which clay is diffused. By a second filtration and crystallization, very pure and white crystals of tartar are obtained; but they are small and ill-shaped, from the quickness of their formation.

This crystallization is partly performed by evaporation, and partly by cold. The part which crystallizes by evaporation forms a saline crust upon the surface of the liquor, called *cream of tartar*; and the part which crystallizes by cold forms small irregular crystals, called *crystals of tartar*; but the name of cream of tartar has prevailed over the latter; so that it is at present applied also to crystals of tartar, and signifies in general purified tartar.

Cream of tartar has a taste sensibly acid; it reddens the blue colors of vegetables; it may be saturated by uniting with any of those substances which are capable of forming with acids neutral salts; and it may be afterwards separated from these substances, and may recover its former appearance. Accordingly, we are certain that this saline matter is an acid. Its property by which it is concrete and crystallizable, it receives from a portion of earth and oil, with which it is intimately combined, and which approximate it to the nature of neutral salts, especially in what concerns the crystallizable quality and the solubility of these salts.

Tartar, although acid, is not very soluble in water; it is even much less soluble than most of the perfectly neutral salts. According to Mr. Spielman's experiment, an ounce of distilled water can dissolve only three grains of cream of tartar, with the heat of fifty degrees of Fahrenheit's thermometer, which is equivalent to the tenth degree of Mr. Reaumur's. By help of a boiling heat, water dissolves much more tartar; but this tartar crystallizes very quickly when the water ceases to boil. The oily part of the tartar seems to be the chief cause of its difficult solubility in water.

Tartar is in a great measure decomposed and totally changed by the action of fire. If cream of tartar be distilled in a retort with a naked fire, a little phlegm will first rise with a gentle heat. When the fire is gradually increased, which must be done very cautiously, on account of the prodigious quantity of air that is disengaged during this distillation, an acid arises in form of white vapors, which are accompanied with an oil, at first thin, but afterwards more and more colored and empyreumatic. In the retort there remains a coal, strongly alkaline, equal in weight to two-thirds of the tartar employed.

The acid obtained in this distillation is indeed oily, and therefore retains the character of a vegetable acid; but it is very different from the tartar itself. It is no longer crystallizable; it is only an oily empyreumatic acid, similar to what is obtained from all other vegetables by distillation in a naked fire. These differences must be attributed to the portion of oil and of earth, which are separated from this acid by distillation. As to the residuum of coal, the fixed alkali, which it contains ready formed, is remarkable, considering that here there is no incineration in open fire, which is generally necessary for the production of alkali from almost all other vegetables. The cause of this difference probably is, that the acid of tartar is almost entirely changed into fixed alkali, is more disposed to be alkali than any other vegetable acid, whether this disposition

disposition proceed from the quantity of earth and oil which are intimately mixed with it, or from some change produced upon it by fermentation. Mr. Spielman thinks, with much probability, that acids are changed into alkalis by the subtraction of a part of their aqueous principle: and the nature and proportion of the constituent parts of tartar appear to be very proper to favour this subtraction of the watery principle by the action of fire. This subject is still obscure, and would require a more profound examination.

**DCLXXIX. TARTAR EMETIC, or STIBIATED TARTAR.** Thus is named the compound formed of the acid of tartar combined with the metallic part of antimony, when this is half deprived of its phlogiston. It is the best and most used of all the emetic preparations of antimony, because the metallic part of this mineral, which gives the emetic quality, is in a saline state, and is perfectly soluble in water.

This preparation has been justly substituted for the golden sulphur, for the regulus, for the liver and glass of antimony, and for the powder of Algaroth. It is infinitely preferable to these preparations for the reasons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we consult the several dispensaries, we shall find very different processes directed: the cream of tartar is employed by all, but some of them require that it should be boiled with the liver of antimony, others with the glass of antimony, and lastly, some with both these preparations. The proportion also of the ingredients, the length of time of boiling, the method of crystallizing and drying the salt after it has been boiled, are different in different dispensaries. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are also certain that the emetic tartars obtained by these several processes are sometimes more and sometimes less emetic; which difference is certainly a great inconvenience for so important a medicinal preparation as this is.

Probably this diversity has been occasioned by persons not considering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being dissolved by the acid of tartar, and forming with it a kind of soluble tartar, a true neutral salt, no less capable of a very exact saturation than the vegetable salt, the salt of Saigette, and all the other soluble tartars. For this saturation being a fixed point, and easily to be found, would probably have been universally prescribed, as is done for all other neutral salts, if it had been well known to have occurred in this instance. But as it is now sufficiently ascertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally strong. Upon this subject we shall add some observations.

First, although regulus of antimony be essentially emetic, it nevertheless produces less effect than the liver or the glass of antimony, because it is less soluble. These two preparations, which are only the metallic earth of antimony deprived of a part of phlogiston necessary to the reguline state, are for that reason more easily soluble by acids than the regulus, and are consequently more emetic. But the glass is still more emetic than the liver, because it has less phlogiston; and it accordingly seems to be the most emetic,  
and

and most soluble in acids, of all the preparations made by fire, general.

Secondly, the end proposed in making emetic tartar, is to make an emetic preparation of antimony, in which the metallic earth is dissolved in an acid, and is soluble in water by means of that acid, and thus is to be free from the inconveniences of the ancient antimonial emetics, the platina, &c. The principal inconvenience of these emetics is, that their effects are very uncertain. Sometimes these effects are not sufficiently strong, but are more frequently too violent. These differences of the same medicinal preparation, given in the same doses, shew that the circumstances on which their action depends are variable. They cannot act internally, till they are dissolved: they can only be dissolved by the acid or other liquors of the body that are capable of attracting them: But the quantity and strength of these dissolving liquors in the body are very variable, according to the different constitutions and states of the alimentary canal. Besides, the greater or less division of these antimonial preparations favors more or less their solution in the body. We need not therefore wonder that their emetic effects should be so variable and uncertain.

These inconveniences are avoided by giving a saline quality to antimonial emetics, by uniting them with the acid of tartar. They then become entirely soluble in water by means of this acid; and the whole quantity of them which is administered produces constant and uniform effects: hence emetic tartar is preferable to all other antimonials that are not in a saline state. But this preparation also must be more or less emetic, according to the quantity of reguline or metallic earth which it contains. Accordingly, Mr. Geoffroy found by examination of several emetic tartars, that an ounce of the weakest of these contained from thirty to ninety grains of regulus, that an ounce of moderate strength contained about 108 grains, and that an ounce of the strongest kind contained 151 grains of regulus. The detail of his experiments may be seen in the *Mémoires* of the Academy for the year 1734.

These differences of strength must proceed from the different methods employed to prepare the emetic tartars, and from the more or less perfect saturation of the acid of tartar.

M. Beaumé affirms from experiment, that this acid may be easily saturated with the reguline part of antimony: and as the glass of antimony is the most emetic and most soluble of all the antimonial preparations made by fire, we ought to prefer it to all others in the preparation of a perfectly neutral antimonial soluble tartar. For this purpose, we must mix together equal parts of cream of tartar and of sublimed glass of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling must be continued gently, till there is no longer any effervescence, and till the cream of tartar be entirely saturated. The liquor is to be filtrated; and upon the filter we may observe a certain quantity of sulphureous matter, together with some undissolved part of the glass of antimony. When the filtrated liquor is cooled, fine crystals will be formed in it, which are a soluble tartar perfectly saturated with glass of antimony. The crystals of this salt have the form of triangular pyramids (*a*). They are transparent while they are

(*a*) The author probably means pyramids, the basis of each of which is a triangle: for every pyramid must evidently have, at least, four solid angles.

moist; but by exposure to a dry air, they lose a part of the water of their crystallization, and become opake and white.

As the perfect saturation of acids requires constantly a determinate quantity of any substance which they can dissolve, we should be certain, by saturating completely cream of tartar with glass of antimony, that the emetic tartar thus prepared would constantly contain the same proportion of emetic antimonial parts. The crystallizing and draining of neutral salts in general, is a good method for obtaining them in their most perfect state: accordingly this salt ought to be first crystallized; but as by exposure to the action of air it is apt to lose some of the water of its crystallization, it ought, immediately after it has crystallized, to be well dried; and then it would remain unchanged. I have frequently administered emetic tartar thus prepared, and I have always observed, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the constitution of the patients.

Authors who have given receipts for the preparation of emetic tartar, have differed, as we have observed, not only as to the kinds and proportions of the antimonial preparations which they direct to be boiled with cream of tartar, but also as to the duration of the boiling. Some of them require that the boiling should last twelve hours, and others only a few instants, believing with Hoffman, that this salt is susceptible of decomposition and of losing its emetic quality by a long continued boiling. Mr. Beaumé has determined this matter by well-conducted experiments, which shew that emetic tartar, like other metallic salts, is capable of being decomposed by other metals to which its acid has a stronger affinity than the metallic basis, and that iron particularly is capable of producing this effect upon emetic tartar; so that if it be boiled a long time in an iron vessel, it is actually decomposed, and the liquor is gradually changed into a tartarised tincture of Mars. But Mr. Beaumé also found that emetic tartar may be boiled during any length of time in vessels made of silver or of glass, without being decomposed.

The results of these experiments of Mr. Beaumé are, 1. That any vessels ought not to be employed in the preparation of emetic tartar; that especially iron, and even copper, ought to be avoided, for this latter metal is found also to act a little upon emetic tartar; and that vessels of silver or of glass ought to be used. 2. That as the intention of the operation is to saturate perfectly the cream of tartar, the boiling must be continued till this saturation be effected, which requires a long time when the glass of antimony is grossly pounded, but a much shorter time when it is well porphyrised, as Mr. Beaumé practises.

We must acknowledge that emetic tartar, prepared by thus saturating completely the acid of tartar with glass of antimony, must be infinitely more uniform in its effect, than what is obtained by any of the other processes hitherto practised. Nevertheless, when we reflect on the nature of the glass of antimony, we cannot affirm that this emetic preparation, notwithstanding its perfect saturation, must always be of equal strength. Glass of antimony is made by fusing the grey calx of antimony, calcined to a certain degree. We know also, that if it be too little calcined, we shall obtain an opake matter, that resembles the liver more than the glass; but that if it be too much calcined, it cannot be vitrified, nor even fused, by the most intense heat. But  
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between the degree of calcination which is sufficient to give an opaque fused matter, and the degree when it begins to be unfusible, there are many intermediate degrees of calcination, all of which are sufficient to produce glasses of antimony; but these glasses differ in degree of transparency, intensity of color, and fusibility, according as the calcination has been more or less complete. We cannot doubt that different glasses of antimony must be more or less emetic, and that perhaps different quantities of these glasses are required for the perfect saturation of the acid of tartar. Besides, we are not only ignorant of the degree of calcination which renders the glass most emetic; but also, if we did know it, we have no certain method of attaining it precisely.

Hence, we are not certain that emetic tartar, prepared by saturating tartar with glass of antimony, has always an uniform and constant emetic power. These considerations have determined me to search, among the several preparations of antimony, for one which should have the same advantages that glass of antimony has, of being convertible into a neutral salt by means of tartar, without the inconveniences of its uncertain degrees of emetic strength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of answering these intentions.

This preparation, which was formerly employed as an emetic, has been justly rejected with the other antimonials that have not a saline quality, because it has the same inconveniences as these have. It occasioned accidents so terrible, that some physicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But these fatal effects do not prevent the possibility of rendering it a good remedy by a proper preparation; in the same manner as glass of antimony, which given singly produced much mischief, has saved many lives since it was converted by its union with tartar into a most efficacious remedy.

Two causes concur in rendering the powder of Algaroth a violent and uncertain remedy. The first is common to it with glass of antimony, and with all the other antimonial preparations that are not saline; and is, its want of solubility in water, for the reasons that we have assigned. The second cause of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of caustic quality. But both these causes of the bad effects of this preparation may be easily and certainly removed. For, by washing it with a little fixed alkali, all the acid may be separated. And I have found from experiments, that the powder thus washed is altogether soluble by cream of tartar, and of being thereby convertible into a soluble emetic tartar, perfectly neutral; for which purpose, nothing more is required than to boil it, and saturate it with cream of tartar, and to treat it in the manner above directed for the preparation of emetic tartar with glass of antimony. We may easily perceive that powder of Algaroth thus prepared is a calx of antimony constantly of the same degree of emetic strength. It is emetic, because the regulus of antimony first dissolved by marine acid, and afterwards separated from that acid, retains the quantity of phlogiston that is necessary to give an emetic quality to the calx of antimony: but the quantity of phlogiston which it retains, and therefore its emetic power, must always be the same: for the marine acid of  
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the corrosive sublimate, which afterwards becomes the acid of the butter of antimony, is always the same in quantity, and in its degree of concentration and of activity: consequently the calx of antimony separated from it must always contain an equal quantity of phlogiston; and is therefore much preferable to glass of antimony, which contains sometimes more and sometimes less phlogiston.

By substituting therefore powder of Algaroth to glass of antimony, and by treating it in the manner above-mentioned, we may obtain the most uniform and certain emetic tartar that can be prepared: physicians, who must be sensible of the advantage of such a remedy, need not be anxious concerning its degree of strength. If it were once known, they would have occasion only to attend to the sensibility or irritability of the constitutions of their patients. *See the articles ANTIMONY, POWDER of ALGAROTH, GLASS of ANTIMONY, and also all the other preparations of antimony.*

DCLXXX. T A R T A R (V I T R I O L A T E D). Vitriolated tartar is a neutral salt composed of vitriolic acid saturated with the fixed alkali of tartar, or with any other very pure vegetable fixed alkali.

This salt is prepared by pouring vitriolic acid into a solution of vegetable alkali, till no more effervescence appears, or till the liquor becomes perfectly neutral, which may be known by the ordinary trial of syrup of violets. From this liquor, filtrated and evaporated, small crystals are obtained, each of which has many sides, sometimes more and sometimes fewer; for the crystallization of this salt varies much in this respect. It is, in general, one of those salts, the form of whose crystals is the least constant. The greatest number of the crystals of this salt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the salts which crystallize better by evaporation than by cold. It requires a large quantity of water to dissolve it. According to Mr. Spielman's experiments, thirty grains only of this salt are soluble in an ounce of water with a heat marked by ten degrees above 0 in the scale of Mr. Reaumur's thermometer. Its taste is moderately saline, and somewhat disagreeable, but not acrid nor sharp. It decrepitates, when heated suddenly and strongly. It contains a small quantity only of the water of crystallization, by means of which it cannot be liquefied; neither can it be fused but by a very intense heat.

As vitriolic acid has a greater affinity with the fixed alkaline basis of the vitriolated tartar than with any other substance, excepting phlogiston, and as this alkali has a stronger affinity with this than with any other acids, hence vitriolated tartar cannot be decomposed but by means of the inflammable principle, as in the process for making artificial sulphur. Mr. Beaumé has indeed discovered that vitriolated tartar may be decomposed in the humid way, by nitrous acid alone, which disengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumstances of this phenomenon, we shall find that this is no exception to the general rules concerning affinities, and that phlogiston is the principal agent in this singular decomposition, as Mr. Beaume has shewn in the explication that he has given of it. (d)

(d) Vitriolated tartar may be decomposed according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into

Vitriolated tartar may also be decomposed by means of a double affinity when it is mixed with solutions of certain metals in acids. But as by phlogiston only metals are dissolved in acids, we need not doubt that this principle has also some influence in these decompositions.

Since vitriolic acid has a greater affinity than any other acid with fixed alkali, we may therefore make vitriolated tartar by applying that acid to any neutral salt composed of an acid and a fixed alkali, as in the decomposition of nitre; and since fixed alkali has a greater affinity with vitriolic acid than any other substance, vitriolated tartar may be therefore made by applying a fixed alkali to any vitriolic neutral salt, the basis of which is not fixed alkali. Accordingly, all vitriolic salts with bases of volatile alkali, of calcareous, argillaceous, or metallic earths, may be decomposed by fixed alkalis; and the compound formed by these decompositions will always be a vitriolated tartar, consisting of the fixed alkali employed in the operation, and of the vitriolic acid of the decomposed neutral salt. Hence we may perceive, that vitriolated tartar is made in many chemical operations.

Before the theory of these operations was understood, and before the fixed vegetable alkali was known to be the same from whatever vegetable it was obtained, the several vitriolated tartars formed in different operations, and with the fixed alkalis obtained from different vegetables, were believed to be different kinds of salts, and were distinguished by different names; as the *sal de duobus*, *sal polychrest* of Glafer, *arcantum duplicatum*. But we now consider all these salts as the same vitriolated tartar, with which the other names are synonymous.

This salt is not of any use in the arts, and is but little used in chemistry. It is principally employed in medicine. Like the other neutral salts with bases of fixed alkali, it is aperitive in small doses, as a gros [72 grains]; and it is laxative, when taken from six gros to twelve. The vitriolated tartar which is prepared by decomposing nitre with vitriolic acid, called *sal de duobus*, has been much celebrated as a remedy against the effects proceeding from an extravasation of a milky humor, for which disease it has been considered as the best resolvent and evacuant. Nevertheless, as Mr. Baron well observes in his Notes on Lemery, no reason can be given for preferring this salt to other neutral salts. On the contrary, as it is one of those which are most perfectly saturated, its action and qualities must be less effectual than most of these. See the articles ACID (VITRIOLIC); ALKALI (FIXED VEGETABLE); CRYSTALLIZATION; and SALT.

DCLXXXI. T E R R A F O L I A T A T A R T A R I; FOLIATED EARTH of TARTAR. This name has been given improperly, and merely for

a matras, and heated till the salt be dissolved. From the liquor, when cold, true crystals of nitre may be obtained. Mr. Beaumé believes that this decomposition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiston, which, he supposes, enters into the composition of the vitriolated tartar: and he thinks that the reason why this decomposition does not happen in the dry way or by fusion, as well as in the humid way or by cold solution, is, that the nitrous acid is in the former case dissipated by the action of the fire. This singular fact,

which seems to contradict a general opinion, namely, that vitriolic acid is more disposed than nitrous acid to unite with fixed alkali, is also confirmed by the intelligent and accurate Mr. Margraaf, who further affirms, that in the same manner of treatment, vitriolated tartar, Glauber's salt, and nitre, may be decomposed by marine acid. As marine acid is certainly not more disposed to unite with phlogiston than nitrous and vitriolic acids are, Mr. Beaumé's explanation of this singular decomposition does not seem to be satisfactory.

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the sake of some earthy appearance, to a *neutral acetous salt with basis of vegetable fixed alkali*, or to a combination of the acid of vinegar, saturated with the alkali of tartar or of other vegetable matters. This salt has also been called *regenerated tartar*, altho' it really be very different from true tartar, but only because the alkali of tartar is united with an acid, which in some respects is similar to the acid of tartar, but in others is very different, as may be seen at the articles *TARTAR and VINEGAR*.

The terra foliata is made, according to most dispensatories, by pouring upon a quantity of alkaline salt of tartar, in a glass-cucurbit, a sufficient quantity of good distilled vinegar, at different times, to saturate all the alkali, or even a little more than is necessary for that purpose, and till the effervescence entirely ceases. This saturated liquor is to be filtrated, and evaporated to dryness, with a gentle heat. The dry salt thus obtained is to be dissolved in spirit of wine, and the solution is to be again evaporated to dryness; by which means a salt is obtained more or less white, of a silky appearance, and composed of small scales or leaves, from which it has been called *foliated*. When the salt is dried, and while it is yet hot, it must be shut up in a well closed bottle, because it quickly becomes moist by exposure to air.

When distilled vinegar is poured upon salt of tartar, little or no effervescence is made at first; but afterwards, when more vinegar is added, the effervescence becomes so considerable, that some of the liquor will flow over the vessel, if care be not taken. This effervescence is produced by a large quantity of air that is disengaged during the saturation. Accordingly the vapor extricated during the effervescence is very *aerial*, and so pungent, that if it be confined some time in a close vessel, and then set at liberty, it is as irritating and suffocating as volatile alkali, or volatile sulphureous acid, although it be really different from either of these: for this vapor is nothing but aerial water similar to the gas of spirituous mineral waters. (e)

When the saturation is advanced to a certain degree, the effervescence diminishes, and even ceases entirely, although the saturation be not yet completed; the reason of which is, that the last portions of acid and of alkali do not very readily combine. The combination may be facilitated by frequently agitating the liquor, by which means the effervescence may be again renewed. When the liquor cannot by agitation be made to effervesce more, it may be then allowed to stand during some time, as Mr. Beaume practises. This chemist, and very excellent observer, has remarked, that the mixture deposits a certain quantity of earthy matter proceeding from the fixed alkali, and which must be necessarily separated by filtration, to obtain a very white foliated earth of tartar. He has

(e) The vapor which causes the effervescence in the preparation of this salt is the fixable air that is disengaged from all mild alkaline substances by means of any acid; and the humid part of this vapor is nothing more than some particles of the effervescing liquor, which are forcibly thrown upwards by the rising air, and which form a small jet or shower above the surface of the effervescing liquor. See AIR (FIXABLE). The reason

that this effervescence does not begin immediately upon pouring on the vinegar, is, that a part of the alkaline salt employed is generally caustic, or deprived of its fixable air, which part unites with the acid preferably to the mild part of the alkali, and absorbs any air that is extricated from this latter part: and therefore till all the caustic part of the alkali be nearly saturated, little or no effervescence can happen.

also observed, that when the alkali employed is very pure, and free from any mixture of neutral salts, the saline matter produced by the process has no foliated or crystallized appearance.

We have already remarked, that foliated earth of tartar is a deliquescent salt. This quality proceeds from the weakness of the union of the acid with the alkali; the cause of which slight union is, that some oily and spirituous principles are united with the acid in vinegar. The taste of the foliated earth is sharp, pungent, almost a little caustic, and partaking at the same time of the taste of vinegar and that of fixed alkali. This salt is one of those that are soluble in spirit of wine. It may be decomposed merely by the action of fire; and from it, as from any other acetous salt, may be obtained by distillation, a radical vinegar, very penetrating and very concentrated.

Foliated earth of tartar is little used, but in medicine. It is considered as a powerful resolvent and aperitive; and it probably possesses these qualities, merely as it retains some of the action of the acid and of the alkali, of which it is composed. Its dose is from fifteen or twenty to thirty-six grains, or even more, when no irritation is apprehended. *See the articles* ALKALI (FIXED); SALT; SALTS (NEUTRAL); *and* VINEGAR.

DCLXXXII. T E R R A J A P O N I C A. *See* JAPONIC EARTH.

DCLXXXIII. T E S T, *and* T E S T I N G. (f)

DCLXXXIV. T I N. Tin is a metal, the color of which resembles that of silver, but is darker and less white. It is softer, less elastic, and less sonorous than any other metal, excepting lead.

When it is bent backwards and forwards, it occasions a crackling sound, as if it was torn asunder.

Tin has, like other imperfect metals, a smell and a taste.

It is much less ductile than some harder metals; although it may be beat into very thin leaves.

The tenacity of the parts of tin is not very considerable, since a wire of this metal, the diameter of which is  $\frac{1}{16}$  of an inch, can support a weight of 49½ pounds only.

It is the lightest of all metals, as it loses only  $\frac{1}{14}$ th part of its weight, when immersed in water. It is very fusible, and requires for this purpose a heat much less than is sufficient to make it red-hot.

With the heat necessary for its fusion it may also be calcined, or at least deprived of so much of its phlogiston that it appears in form of a grey calx, which cannot be reduced entirely to tin without the addition of some inflammable matter.

Workmen call this imperfect calx of tin, *ashes of tin*; and those who travel in the country, casting tin spoons, call it *drofs of tin*. This they carefully skim off, pretending thereby to purify their tin. But they preserve this pretended drofs, and reduce it to tin by melting it with some pitch.

These ashes of tin, like other calxes of metals, may be further deprived of phlogiston, by a calcination continued with a more intense fire, by which means

(f) TEST and TESTING. A test is a large kind of cupel used in operations for refining large quantities of gold and silver by means of lead; and the operation is called *testing*. *See* CUPEL; CUPELLATION, *and* REFINING.

it becomes more and more white, hard and refractory. It is then called *putty*, and is used in the arts for polishing glass and other hard bodies.

Calx of tin, very white and well calcined, is a very refractory substance. Its beautiful whiteness and refractory quality render it capable of forming, together with some fusible and vitrifiable matters, a white enamel, which is used as a white glazing or covering for delf-ware. See Delf-ware.

The most ordinary method of preparing this putty, is by mixing together lead and tin, and exposing this mixture to a strong heat. These two metals have been found to be more easily calcinable when mixed than when single. By adding to the calx thus obtained some sand and vitrifiable salts, and by fusing the mixture, a very beautiful white enamel may be made: for lead does not, like tin, lose its fusible quality by calcination.

I have exposed very pure tin, singly, to a fire as strong as that of a glass-house, during two hours, under a muffle, in an uncovered test; and having then examined it, I found it covered with an exceedingly white calx, which appeared to have formed a vegetation; and under this matter, a reddish calx, and a transparent hyacinthine glass; and lastly, at the bottom, a piece of tin unaltered. This experiment was several times repeated with the same success.

Nine mixed with tin may be inflamed, and it hastens considerably the calcination of this, as it does of other imperfect metals. The vapors which rise during the several calcinations of this metal have generally an alliaceous or arsenical smell; because tin generally contains some arsenic, as Mr. Margraaf has observed.

Although tin be one of the most calcinable metals by means of fire, it is much less apt to rust by the combined action of air and water, than iron and copper. Its surface, when it is clean and shining, loses indeed its lustre, and tarnishes quickly by exposure to air, but the slight kind of rust which is there formed remains thin and superficial, and does not advance so deeply into the substance of the metal as the rust of iron and of copper generally does. Hence tin is advantageously employed to cover many utensils made of these metals. See Tinning.

Every acid is capable of attacking or dissolving tin.

Vitriolic acid requires to be assisted by a certain degree of heat to dissolve tin efficaciously. I have observed, that during this solution sulphureous vapors are raised; and I have even separated some black particles, which I have found to be true inflammable sulphur. The production or extraction of this sulphur requires a particular examination. See Sulphur.

Nitrous acid attacks tin with very great violence, especially when the metal is much divided. But when the acid is very pure, it rather corrodes and calcines than dissolves tin. As the phlogiston of this metal is not very strictly engaged, the nitrous acid chiefly attacks it by means of this principle, which it seizes, and separates from the tin, that is thus reduced to an insoluble white earth, or calx, deposited at the bottom of the acid. This calx of tin made by nitrous acid appears to be as perfectly dephlogisticated, as that which had been exposed during a long time to fire. I have attempted unsuccessfully to reduce it to its metallic state. This calx makes a very good white enamel.

The acid of common salt dissolves tin perfectly well by help of heat. I have observed, that when I put a considerable quantity of fine granulated tin into a matrafs, and poured some smoking, and consequently colored, spirit of salt upon it, that the acid quickly ceased to smoke, and lost its color; that it attacked the tin with a sensible but moderate effervescence, and became saturated with it. This acid dissolved more than half its weight of tin. The vapors which rose during the solution had a disagreeable arsenical smell; and the solution when saturated was clear and colorless as water. Having kept the solution in a bottle, I observed that, during the winter, it almost all crystallized, and that the crystals became fluid during summer. Some years afterwards a white sediment was formed in this solution.

Tin has a greater affinity with marine acid than some other metallic substances which have also much affinity with this acid; for it separates the marine acid from luna cornea, from corrosive sublimate, and from butter of antimony. When tin is mixed, especially with corrosive sublimate, it decomposes this salt, even without heat; and the mixture produced becomes moist by exposure to air. If it be distilled before it has imbibed much moisture, a very smoking spirit of salt, called *smoking spirit of Libavius*, is obtained. See SPIRIT (SMOKING) of LIBAVIUS.

This acid retains much tin dissolved, some of which it raises along with it in distillation, as it does several other metallic matters. Accordingly, in this distillation, a concrete, saline, metallic matter is sublimed, that may be called *butter of tin*: which name has been given by some chemists to the smoking spirit.

From the detail we have given of the solutions of tin by nitrous and marine acids we may perceive, that the former acid deprives it of all its inflammable principle, but has no action upon its dephlogisticated earth; and that the effects of the marine acid upon this metal are quite the reverse. Accordingly, when these two acids are united together, forming an aqua regia, they compose a menstruum, which acts very efficaciously upon tin, on account of the activity of the nitrous acid, but which does not destroy the metal, as nitrous acid singly does, because the action of this acid is moderated by the marine acid: hence, the more nitrous acid is contained in aqua regia, the more similar are its effects upon tin to those produced by nitrous acid alone; and reciprocally with regard to marine acid.

A good solution may be made of tin in aqua regia, if attention be given to the following particulars. A small quantity only of tin ought to be put into the acid, and no more added till the first piece be entirely dissolved; because when much tin is added at once, the heat occasioned by the solution encreases the activity of the solvent so much, that the tin is as much calcined and precipitated as if pure nitrous acid had been employed; but when the tin is added gradually, and the heat is thus restrained, the aqua regia may be so charged with this metal, that it shall be thick and viscid, like a liquid transparent resin. The solution thus charged has a yellow-reddish color.

We may observe, that in this solution there is a considerable quantity of tin upon which the nitrous acid of the aqua regia has not exhausted all its action, although this menstruum seems to be more than saturated; for I have observed, that when this liquor is heated, an effervescence happens entirely similar to that which

which is occasioned during the solution of metals by acids. This effervescence lasts till the parts of the tin which were only half dissolved have been redissolved a second time; after which the solution is found to have lost its color. Sometimes this solution becomes quite fixed or solid when it cools, and appears like a firm jelly, and transparent as crystal.

All the solutions of tin are acid and corrosive; and may be decomposed by being diluted with much water; in which case, the tin is copiously precipitated in form of a white calx.

When a solution of tin is mixed with a saturated solution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Cassius*. See that word. This powder is employed for painting on enamels and on porcelain.

The solution of tin in aqua regia, added to the tinctures of cochineal, of gum lac, and of some other red tinctures, heightens the color of these, and changes it from a crimson or purple to a vivid reddish-yellow or fire-colored scarlet. Dyers call this solution of tin, with which they give a scarlet tinge, *the composition*. We may observe, that this color succeeds only with wool and other animal matters. Attempts have been made, but without success, to give this color to thread, to cotton, or even to silk, although this latter substance has many properties of animal matters.

I have also observed, that the larger quantity of nitrous acid is contained in the aqua regia, which dissolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow; so that the solution of tin made with marine acid alone, or with vitriolic acid, do only give to red tinctures a crimson color, as alum does. See DYING.

Vegetable acids, as vinegar and cream of tartar, are also capable of dissolving tin: but the properties of these solutions have not yet been well examined.

Tin, according to Mr. Geoffroy's table of affinities, has a stronger affinity with the acid of common salt than regulus of antimony, copper, silver, and mercury; because the combinations of this acid with these metals are decomposed by tin, which precipitates them, and unites with the acid.

Sulphur may be united with tin by fusion, and forms with it a brittle mass, more difficultly fusible than pure tin. Sulphur has in this respect the same effect upon tin as upon lead. The alloy of sulphur lessens the fusibility of these very fusible metals, while it increases the fusibility of other difficultly fusible metals, as of iron and copper.

Tin may be alloyed with all metals by fusion, and in all proportions; but it absolutely destroys their ductility. A remarkable circumstance is, that the most ductile metals, as gold and silver, are those the ductility of which is most injured by tin. The vapor of a single grain of tin is capable of rendering a considerable quantity of gold brittle. The ductility of copper is less injured by tin than that of other metals, although it is considerably injured. A singular circumstance concerning this alloy is, that tin, although a very soft metal, and not at all sonorous, augments considerably the stiffness, the hardness, and the sonorousness of copper, as we see in *bell-metal*.

The alloy, or amalgam of tin with mercury, is employed to cover one of the surfaces of looking glasses, by which they are rendered capable of reflecting the

rays of light, and of forming mirrors. This covering of tin and mercury, which is applied upon glasses, is called *tinning*.

Tin, alloyed with an equal quantity of lead, forms the solder used by plumbers.

According to Mr. Gellert's table, the affinities of tin are, iron, copper, silver, and gold. See, for the alloys of tin, the words ALLAY, AMALGAM, and BRONZE.

Tin is not much used in medicine, and for good reasons: for we find, from a long Dissertation by Mr. Margraaf upon this metal, that tin generally contains more or less of an arsenical matter, which probably proceeds from the ores of tin, as all these contain arsenic. See ORES, and SMELTING of ORES. Mr. Margraaf discovered this arsenical part of tin chiefly in the humid way, and by solution in acids. The white calx of this metal is commonly employed in the preparation of the *antibætic of Poterius*, and of the *lilly of Paracelsus*: but this calx is insoluble and ineffectual; besides, it appears to furnish no part of the lilly.

Tin is very extensively useful in many arts, as we may judge from what has been said of the different preparations of this metal.

DCLXXXV. **TINNING of COPPER, and of IRON.** Tinning is an operation by which a very thin layer of tin is applied to the surface of some metals, and especially of copper and of iron. The methods of tinning these two metals are different. Copper is tinned after it has been formed into utensils, and by the copper-smiths who form these utensils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in some other places. Workmen, called *tin-smiths*, do only form these plates, which are brought ready made from their proper manufactories, into the various utensils required.

The several operations for tinning of copper and iron are founded, first, on the facility with which tin unites with these metals, which is so great, that when either of these metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheless, the tin incorporates with these metals, dissolves in some measure their surface, and forms a kind of alloy, at least when the tinning is well performed.

Secondly, the foundation of all the parts of the operation used to make the tinning succeed is, that metals cannot perfectly unite with each other but when they are in a metallic state, and that they cannot unite with any earthy matter, not even with their own earths or calxes.

Hence, the whole art of tinning consists in applying melted tin to the surface of which shall be very clean, metallic, and not covered with any ashes or calx of tin, to the surface of iron or of copper, which must also be very clean, and free from all rust or calx.

To attain these purposes, the following method is used. As the surface of copper is continually altered merely by the action of air, the workmen, before the tinning of any vessel, scrape its surface with a steel instrument till it be clean and bright: then they place the vessel upon kindled coals, and heat it to a certain degree: as soon as it is hot, they rub it with pitch, and then apply the melted tin, which they spread upon the surface of the copper by

by means of hards. Pure tin is seldom used for this purpose; but generally two parts of tin are alloyed with one part of lead.

The pitch used in this operation is quite necessary, because the degree of heat given to the copper is sufficient to calcine its surface in some measure; and this alteration, however slight, would prevent the perfect adhesion of the tin, unless, by means of the pitch, the phlogiston was restored to it at the very instant of the application of the tin. This pitch prevents also the slight calcination which would happen on the surface of the tin, or revives the small particles of calx which are formed during the operation.

When plates of iron are to be tinned, they must be perfectly well cleansed, which is done by scouring them with sand, and sleeping them some time in acid liquors: then they are to be wiped, and dried quickly and perfectly. Lastly, they are to be plunged vertically into a vessel containing melted tin, the surface of which is covered with fat and pitch. These fat substances covering the surface of the tin, supply it continually with phlogiston, prevent its calcination, by which its adhesion to the iron would be impeded, and also render the surface of the iron, while it passes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is also used successfully in the tinning of iron and of copper, and always for the same reason. The acid of this salt perfectly cleans the surface of the metals to be tinned, and also the oily matter contained in sal ammoniac furnishes the phlogiston that is necessary in this operation. Thus, by heating these metals to a certain degree, and rubbing them with sal ammoniac, the tin may be applied immediately afterwards.

The advantages derived from tinning are very considerable. As tin is a soft and fusible metal, vessels formed of it alone would not have sufficient strength and hardness to keep their shape in common use, and would also be liable to be melted with a fire it bears: but when it is applied to the surface of hard and difficultly fusible metals, as copper and iron, many vessels may be fabricated, which have the advantage of being preserved, by means of the tin, from rust, to which the copper and iron are very subject. It has been, nevertheless, justly alledged, that copper vessels are not perfectly prevented from rust or verdigris by tinning; and this fault is so much more important, as tinned copper vessels are generally used in the preparation of victuals. These vessels therefore, even when tinned, ought not to be employed for this purpose; especially as tin itself is suspected of being hurtful to health, since Mr. Margraat discovered that arsenic is contained in almost all tin; and also because lead, a most hurtful metal, is used in tinning. Nevertheless, tinned copper vessels may be used for many other purposes. Besides, the tinning of copper and iron vessels may be improved, by attending to the fundamental principles of this art delivered in the present article.

**DCLXXXVI. TINNING of LOOKING-GLASSES.** This operation consists in applying an amalgam of tin and mercury upon one of the surfaces of looking-glasses, by which they are rendered much more capable of reflecting the rays of light, and consequently of representing, in a clear and lively manner, the images of objects.

This effect of the tinning of looking-glasses is founded on the superior opacity, and consequently on the superior reflective power of metallic to all other substances.

Glasses to be tinned are placed upon tables, in a perfectly horizontal or level situation. The surface, previously well cleaned, is to be covered with tin-leave, which also must be very clean. Upon these is poured a sufficient quantity of mercury to cover the whole surface, and it is allowed to rest some time, that it may amalgamate perfectly with the tin-leaves: then a small degree of inclination is given to the glass, that the superfluous mercury may run off; which inclination must be gradually encreased till the glass be at last brought to a vertical situation, by which means no more mercury remains than is really amalgamated with the tin. As the surface of the glass is exceedingly smooth and well polished, the amalgam is in very perfect contact with it, and therefore firmly adheres to it.

The success of this operation depends much on the cleanness of the surface of the glass; for the least dirt or dust interposed betwixt the amalgam and the surface of the glass would absolutely prevent the adhesion of contact between these two bodies.

Since vitrified matters, as glasses are, cannot unite intimately with metallic substances, the adhesion of the amalgam upon the glasses is not so strong as that of metals upon metals; as in the tinning of copper and of iron, in which there is a solution, a penetration, and an intimate union of the tin with the surface of the tinned metal: but in the tinning of looking-glasses, there is only the adhesion of contact, or of a perfect juxtaposition, which may take place between any bodies, however heterogeneous, by the application of their polished surfaces. Accordingly, this metallic covering may very easily be taken off, and ought to be preserved from moisture, and from any kind of rubbing, however slight. For which reason, the superfluous mercury must be made to run off very gently and slowly, otherwise all the amalgam might fall off by its weight.

DCLXXXVII. T I N C A L. (g)

DCLXXXVIII. T I N C T U R E. By this name are distinguished, in chemistry and pharmacy, all spirituous liquors that are colored by being digested upon different substances. These are, properly speaking, infusions in ardent spirits.

Many chemical preparations are called *tinctures*. We shall treat of some of the chief of these.

DCLXXXIX. T I N C T U R E (A L K A L I N E). See TINCTURE of SALT of TARTAR.

DCCXC. T I N C T U R E of A N T I M O N Y. This tincture is made, according to the Paris Dispensatory, in the following manner: Let a mixture of one part of crude antimony with two parts of the alkali

(g) TINCAL. Borax, in the crude state in which it is brought from India, and before it is refined, is called tincal. It consists of small crystals, of a yellowish color, and it has a greasy or unctuous touch. According to Mr. Cadet, it contains a larger quantity of the peculiar vitrescible earth of borax, than the refined salt commonly sold does. See BORAX, and SALT (SEDATIVE).



The Salt of tartar, be fused in a covered crucible, and the fusion continued during an hour. The melted matter is to be poured out; and as soon as it has become solid, it is to be pulverised: while yet hot, it is to be put into a matras; and upon this powder rectified spirit of wine is to be poured, to a height above the powder equal to the breadth of three fingers. This tincture is to be digested with a gentle heat during several days, by which it acquires a deep red color; and then it is to be decanted and preserved in a well-closed bottle.

In this fusion of crude antimony with fixed alkali, a liver of sulphur is formed, which dissolves the reguline part of antimony. It is consequently an antimoniated liver of sulphur, nearly of the same nature as that of which *kermes mineral* is made: but in the present operation this matter is not dissolved in water, but is digested in spirit of wine; which menstruum seems to dissolve a part of the whole matter, that is, a part of the liver of sulphur, and by means of it also some of the regulus of antimony; for this tincture acquires a red color, and produces nausea, according to Lemery, when taken internally. According to the same author, the dose of this tincture is from four drops to twenty, and is to be administered in some proper liquor.

The medicinal effects of this preparation may be very good, and analogous to those of kermes; but it is not much used. *See KERMES (MINERAL).*

This solubility of antimoniated liver of sulphur in spirit of wine is remarkable: but an explanation of all the appearances that occur in this and in several other operations, would require more particular researches than have yet been made.

**DCXCI. TINCTURE of MARS.** Iron, being a metal much employed in medicine, has been prepared in various manners for internal use. Amongst the principal of these are the following tinctures.

**DCXCII. TINCTURE of MARS (LUDOVICUS's).** This tincture is made, according to the Paris Dispensatory, in the following manner: Four ounces of martial vitriol calcined to whiteness are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the consistence of honey. This mass is to be put into a matras, into which some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. After a digestion during some time in a sand-bath, the tincture is to be decanted, and fresh spirit of wine is to be poured on the residuum, and digested as before. These operations are to be continued as long as the spirit of wine acquires color; and, lastly, all these tinctures are to be mixed together and preserved for use.

The theory of this process is not well known; because all the circumstances have not been examined with sufficient attention. We see, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very strongly to the vitriolic acid, or which is even quite disengaged from that acid by calcination; and that this combination of iron with cream of tartar may be soluble in spirit of wine, to which it may communicate color, and consequently may form the present tincture: but does not the cream of tartar act also upon the iron which is united with the vitriolic acid; and if it does not act, does the martial vitriol dissolve in spirit of wine?

If it does not dissolve in this spirit, when it is single and in its ordinary state, and charged with much iron, may it not become soluble either when it has deposited a part of its iron, or by means of the acid of tartar? These are questions which, I believe, have not been yet examined; but which must be ascertained, before we can know precisely the nature of this tincture of Mars. For its medicinal virtues, *see the article IRON.*

**DCXCI. TINCTURE of MARS of MYNSICHT.** This tincture is made by digesting the martial flowers of sal ammoniac with a sufficient quantity of rectified spirit of wine in a matras.

Spirit of wine dissolves the salt formed by the union of iron with the acid of sal ammoniac; but as this spirit can also dissolve the sal ammoniac itself, it may be charged with a certain quantity of the latter salt in this operation: it is even very possible, that by means of this sal ammoniac, it dissolves a greater quantity of the martial salt than it would otherwise do; and reciprocally, that the martial salt puts it in a condition of dissolving a greater quantity of sal ammoniac; which effects are similar to those produced by treating in the same manner corrosive sublimate and sal ammoniac in spirit of wine: but I do not believe that any researches have been made to elucidate this subject. Chemists, who have given receipts for most of the medicinal preparations of the kind of which we now treat, made frequently capricious mixtures, the effects of which they did not know. These preparations have been consecrated by use, although little trouble has been taken to ascertain their nature: but now that chemistry, taken in its true and genuine spirit, has become a science as accurate and rigorous in some measure as geometry, all these ancient receipts ought to be scrupulously examined. We should then certainly reject many of these for their unsuitness to produce the effects expected, and we should know better the virtues of those which should be judged worthy to be retained in use. Probably the tincture of Mars of Mynsicht possesses the medicinal qualities of iron dissolved by marine acid, and of sal ammoniac.

**DCXCIII. TINCTURE of MARS (ALKALINE) of STAHL.** This preparation, the knowledge of which Stahl has communicated to us, is a solution of iron in fixed alkali. Although this saline substance be capable of acting directly upon iron, and of dissolving it in some measure, this combination succeeds much better when the iron to be united with the alkali is previously divided by being dissolved in an acid, and especially in vitriolic acid, as Stahl has shewn.

According to the process of this celebrated chemist, the iron ought to be previously dissolved in nitrous acid, and the solution ought to be as perfectly saturated as possible. This saturated solution is to be added at several different times to a strong solution of vegetable fixed alkali. Each time that the solution of iron is poured into the alkaline liquor, a kind of precipitate or coagulum of a deep red saffron color is instantly formed: but this precipitate disappears soon after, and dissolves entirely in the alkaline liquor, to which it communicates a deep-red yellowish color. More of the solution of iron is to be poured into the alkaline liquor, till the precipitate is no longer redissolved. Lastly, this solution, which is the martial alkaline tincture of Stahl, is to be filtrated.

We may easily conceive what passes in this process. The alkali, into which the combination of iron with nitrous acid is poured, decomposes at first this combination,

combination, by uniting with the acid, and precipitating the iron. But as there is much more alkali than is required to saturate the quantity of acid added, the uncombined portion of alkali finding the iron in a very divided state, attacks and dissolves it perfectly.

Iron is not the only metal that may be thus dissolved by an alkali. Almost every metal is more or less soluble by alkalis, as Mr. Margraaf has shewn. *See his Opuscles Chymiques, Diff. III.* This celebrated chemist found that not very pure alkalis but alkalis phlogistified by calcination with ox's blood and volatile alkali, were fit for this purpose.

This solution of iron in fixed alkali does not always succeed, and even sometimes fails, when all the circumstances directed by Stahl have been observed. I have remarked, and also Mr. Beaumé, that it succeeds much more constantly, and almost certainly, when a solution of iron not nearly saturated and very acid is employed; and when the solution has not the reddish-yellow color of rust that saturated solutions have, but is clear and limpid, or only slightly greenish. We were also induced to believe, that a similar excess of acid was favorable for redissolving other metallic precipitates from their acid menstrua by means of alkali; and even that without this excess, the operation cannot succeed. But Mr. Marges, an intelligent chemist, has shewn me a solution of iron much impregnated, and high-colored, the iron of which might be perfectly dissolved by fixed alkali, without heat; and which constantly formed the martial alkaline tincture, either by pouring the solution to the alkali, or the alkali to the solution; which proves that this phenomenon depends on the concurrence of several circumstances; as on the state of the iron in the nitrous acid, which is known to be very variable; on the greater or less phlogistification of the alkali; and perhaps also on several other circumstances, which ought to be more fully examined, before we can form a judgment.

The martial alkaline tincture certainly contains an iron very much divided, in a saline and perfectly dissolved state, though it is not united to any acid; and as it also possesses a saponaceous alkaline character, it may be very useful in all cases where martial and anti acid remedies are at the same time indicated: and these cases are very frequent, as practical physicians well know.

A very fine saffron of Mars may be separated from this solution, either by precipitating the iron by gradually saturating the alkali with any acid, or by a spontaneous deposition of a ferruginous sediment, which is slowly formed in this, in the same manner as in the acid solutions of iron. We shall only observe, that the iron which has been thus dissolved by an alkali is very soluble in acids; so that when it is to be precipitated by an acid, we must take care not to add a drop more than is necessary for the perfect saturation of the alkali, otherwise all the precipitate instantly disappears, and the liquor becomes clear and almost colorless. *See ALKALI and IRON.*

DCXCIV. • T I N C T U R E of MARS (FARTARI SED). This preparation, like the preceding, is called a tincture, although it contains nothing spirituous, but is merely from its deep color. It is a solution of iron by the acid of tartar; and is a true *Martial soluble tartar*, as we shall see.

This combination is made, according to the Paris dispensatory, in the following manner. Six ounces of clean filings of iron, and a pound of powdered white  
tartar

the above to be mixed together in an iron vessel; the mixture is to be moistened with a sufficient quantity of water to form it into a mass, which must be left undisturbed during 24 hours, that the acid of tartar may begin to act upon the iron. Then six Paris pints [12 pounds] of pure water are poured on the mixture, and boiled together during two hours. From time to time the mixture must be stirred during the boiling, and hot water is added to supply the place of that which is evaporated. The liquor is then to be left to settle, and to be filtered and evaporated to the consistence of a liquid syrup. Lastly, an ounce of spirit of wine is to be added to it, to prevent the solution from becoming insoluble.

In this operation, the acid of tartar dissolves the iron, becomes saturated, and forms with it a neutral salt, which is not only very soluble in water, but which is even very deliquescent: hence this salt cannot be crystallised, but is obtained in the state of a liquor, or of an extract. Sometimes dry and sometimes salt, according as it has been more or less evaporated. The color of this salt is red, or brown, and its taste is the same as that of all salts the bases of which are iron, though somewhat less austere and styptic.

The union of the acid of tartar with iron is very weak and very superficial in this combination; and hence this salt is very deliquescent. This deliquescence is surprising, considering that, as we have remarked elsewhere, the two substances which compose it have little or no solubility in water. From this difficult solubility in water of the component parts of the tartarised tincture we may conclude, that in whatever proportions these parts are mixed together, this tincture must always be a neutral salt, perfectly or nearly saturated: for if any portion of tartar be not combined with the iron, it will remain at the bottom of the vessels, or upon the filter; and the same observation may be applied to the iron that is not combined with the tartar. Nevertheless, as pure tartar is soluble in water, and as consequently a small portion of it may remain unsaturated in the liquor, it would be proper, if this martial soluble tartar be required perfectly neutral, to add more filings of iron than are sufficient to saturate all the acid; because the superabundant quantity could not remain in the solution, and because by this method of employing a large quantity of filings, the operation may be much shortened; whereas it would be very long, if no more filings were employed than is required for the saturation of the tartar, and if at the same time all the tartar was required to be saturated.

The tartarised tincture of Mars has the same medicinal qualities as the other saline and soluble preparations of iron; but it is, as we have said, the least styptic. Accordingly, in cases where martial preparations are indicated, and at the same time the styptic quality of iron is apprehended, this is one of the best preparations of iron that can be prescribed. It does not essentially differ from the infusion of martial balls. See IRON, and TARTAR.

DCXCV. TINCTURE of METALS, or LIQUOR of PARACELSUS. This preparation may be made by several processes; but as they do not much differ, we shall here give the easiest and readiest.

Two parts of martial regulus of antimony, one part of fine tin, and one part of pure copper, are melted together in a crucible. The alloy thus compounded

pounded is to be powdered, when cold, and mixed with thrice its weight of purified nitre. The mixture is to be thrown at different times into a red-hot crucible, where it detonates, and is exposed to a violent fire, till the metals be perfectly reduced to calxes. The matter is to be taken from the crucible while red-hot, and immediately thrown into a heated iron mortar, where it is quickly powdered. The powder is to be put, while yet hot, into a matrafs, and upon it some rectified spirit of wine is to be poured to a height equal to the breadth of four fingers. The digestion is continued during some days, or till the spirit of wine has acquired a very deep yellowish red color. The spirit is to be decanted and kept in a bottle; and is called the *Tincture of Metals*, or *Lilis of Porcellus*.

From this name *Tincture of Metals*, we find that the spirit of wine was supposed to extract something from the metals on which it is digested in this process; perhaps its color gave rise to this opinion. Nevertheless, as Mr. Baron well observes in his *Notes on Lemery*, if we consider that the metallic matters are reduced almost to the state of pure earths by calcination, we shall be convinced that no part of them can be dissolved by the spirit of wine. Besides, Mr. Beaumé, having particularly examined this preparation, was convinced by experiments that no metallic matter can be separated from it. But although it contains no metallic matter, we do not say that it is ineffectual, or that it has no other qualities but those of the pure spirit of wine. On the contrary, we know that the nitre is alkaliified in this operation; and that this alkali, which is capable of being rendered as caustic by metallic calxes, as it is by quicklime, acquires a power of acting singularly and effectually on spirit of wine, which it partly decomposes. This alkali either forms with the spirit of wine, or it separates from this spirit, an oil, with which it combines, and to which it gives color, and a very acrid taste. Hence the tincture of metals resembles much the *tincture of salt of tartar*, of which we shall afterwards treat, and like which it has a spirituous, saponaceous, acrid, and alkaline character. Accordingly, it is successfully used when the fibres and vessels require to be excited and animated; as in apoplexies, palsies, drop-sies. For the same reason, it is capable of accelerating the motion of the blood, and of encreasing certain secretions and excretions, particularly sweat and urine. The dose of this tincture is from six or twelve drops to forty or even more, and it must be administered in some proper cordial.

DCXCVI. *TINCTURE of GOLD. See GOLD (POTABLE).*

DCXCVII. *TINCTURE of SALT of TARTAR.* This tincture is made by pouring some rectified spirit of wine to a height equal to the breadth of three or four fingers, into a heated matrafs that contains some hot salt of tartar, which had been previously fused in a crucible and powdered. The matrafs is to be closed, and the digestion is to be continued during several days with a gentle heat, or till the spirit of wine has acquired a fine reddish yellow color.

Its preparation is essentially the same as the tincture of metals, as in both these, the fixed alkali acts upon and colors the spirit of wine; with this difference only, that as the alkali of tartar, in its ordinary state, is much less caustic than when it has been calcined with metallic calxes, it therefore acts less quickly

and powerfully in the tincture of salt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of salt of tartar, an alkali previously rendered caustic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of these two tinctures are the same.

**DE XCVIII. TINCTURES of VEGETABLE and ANIMAL SUBSTANCES.** Many medicinal preparations are called tinctures, because they are made by digesting certain vegetable and animal substances in spirit of wine, to which they communicate different colors, according to their nature.

Some of these tinctures are made with one vegetable or animal substance only. These are called *simple tinctures*, and they are distinguished by the name of the vegetable or animal matter employed; such are the tinctures of myrrh, of aloes, of saffron, of castor, and many others.

Others contain a greater or less number of different vegetable and animal substances, which are digested in spirit of wine, according to the several receipts. These have the general name of *compound tinctures*, and are also distinguished by the names of their particular authors and qualities.

We shall not here enter into a detail of these several tinctures, because they are rather objects of pharmacy than of chemistry; but shall confine ourselves to the following general observations.

First, as vegetables and animals are composed of several principles which are not all soluble, or not equally soluble in spirit of wine, we cannot consider spirituous tinctures as complete extracts of the vegetable and animal substances employed in their preparation.

Secondly, the principles of these substances upon which spirit of wine can act, are volatile essential oils, and others of the same nature; resins, properly so called; any oils that are in a saponaceous state, and soluble in water by means of some saline matter; acids; and lastly, several kinds of neutral salts. And the principles which spirit of wine cannot dissolve directly are sweet oils and oily concretions that are not volatile nor saline; substances purely gelatinous and gummy; earthy matters not saline nor soluble in water; and lastly, many neutral salts, which are insoluble in spirit of wine, the varieties of which have not yet been determined.

Thirdly, many of the vegetable and animal principles that are essentially insoluble in spirit of wine, particularly gums, jellies, and neutral salts, are soluble in water.

Fourthly, from the last observation we may perceive, that tinctures made from the same vegetable or animal substance must differ considerably according to the state of dryness of these substances, and the dephlegma of the spirit of wine employed. For a tincture made from moist plants, and with a weak spirit of wine, must contain some gummy and saline principles, which could not be contained in a tincture made with the same plants perfectly dried, and a spirit of wine perfectly rectified.

Fifthly, as many chemical experiments shew that substances naturally insoluble in any certain menstruum, may be rendered soluble in that menstruum by

by some other intermediate substance; and as, amongst the vegetable and animal principles, some such intermediate substances may exist; we cannot therefore affirm that spirituous tinctures contain no other of these principles but such as are naturally soluble in spirit of wine; but we rather think that they probably do contain other principles. This subject has not been examined sufficiently to enable us to speak upon it in a less vague and general manner than we now do. See ANALYSIS by MENSTRUUMS, and SPIRIT (ARDENT).

DCCXCIX. T I N - G L A S S. This name is frequently given to the semi-metal bismuth. See BISMUTH.

DCC. T O B A C C O. (b)

DCCCL. T O P A Z. (i)

DCCCL. T O R R E F A C T I O N. This name is given to a kind of calcination by which ores are deprived of the volatile mineralising substances, the sulphur and arsenic which they contain. It is also applied to signify the roasting of some pharmaceutical preparations. Thus, for instance, we say *torrefied rhubarb*, &c.

DCCIII. T R A G A C A N T H (G U M). See GUM.

DCCIV. T R I P O L I. (k)

DCCV. T R I T U R A T I O N is an operation which consists in the mechanical division of bodies, and is executed by the same methods, and by the same instruments, that are employed for other divisions of this kind; that is to say, in mortars, upon porphyries, and in mills. See DIVISION. This word is generally applied to denote the division that is made of several bodies together, to unite them with each other; as, for instance, the extinction of mercury in the operation of ethiops mineral, and others similar.

DCCVI. T U R B I T H M I N E R A L. This name is given to a preparation of mercury made in the following manner.

(b) TOBACCO. The leaves of this plant being distilled in a retort, without addition, yield an acid, empyreumatic, poisonous oil. Tobacco loses its virulence by long coction in water. From an ounce of American tobacco, water extracted four drams and thirty grains; and from an ounce of the same tobacco, spirit of wine extracted one dram and thirty grains. The spirituous extract was stronger than the aqueous. The former had a fine green color; the latter was yellowish-brown. The distilled water and spirit of tobacco have no taste or smell. *Neuman*.

(i) TOPAZ is a precious stone, of a golden color, the fourth in hardness from diamonds. Mr. Pott has made some curious experiments on the Saxon topaz. He found that this stone could not be fused with even eight times its weight of fixed alkali, but that it was vitrifiable by addition of half its weight of borax, or of thrice its weight of chalk. It was also fused by calxes of lead or of copper, and by fusible spar, but not by nitre.

This stone may be imitated by fusing a

mixture of two ounces of powdered rock-crystal with seven ounces of red-lead.

(k) TRIPOLI is an earth consisting of very fine particles. It is used for polishing hard bodies. Tripoli is not fusible in the fire. Its colors are various; grey, yellow, white. It becomes more hard and compact in the fire, as clay does; and from this property probably it has been considered as an argillaceous earth; tho' it does not appear to have been sufficiently examined. It has been imagined to be a powder formed by the decomposition or mouldering of jasper. *Neuman* says, that by distilling two ounces of it, he obtained two scruples of a weak marine acid, and a small portion of sal ammoniac; that by distilling a mixture of this earth and nitre he obtained an aqua regia; and that of sixty grains of Tripoli, one grain was soluble in concentrated vitriolic acid, two in diluted vitriolic acid, three in spirit of salt, five in spirit of nitre, eleven in aqua regia, and seven grains in caustic fixed alkali.

Some mercury is put into a glass-retort, and upon it is poured an equal weight of concentrated vitriolic acid, or more, according to the degree of concentration of this acid. These matters are to be distilled together in a sand-bath till nothing remains in the retort but a dry saline substance, which is a combination of mercury with vitriolic acid. The union of these two matters cannot be directly effected but by this process, because the vitriolic acid cannot attack mercury unless it be highly concentrated, and because this concentration cannot be performed so well in open as in close vessels. See CONCENTRATION. Besides, the heat in this operation favors considerably the action of the acid upon the mercury. The acid which passes into the receiver during the distillation, is very suffocating and sulphureous; which qualities it receives from the phlogiston of the mercury.

The white saline mass left at the bottom of the retort is to be put into a large vessel, and upon it large quantities of hot-water are to be poured at several different times. This water weakens the acid, takes it from the mercury, which is then precipitated towards the bottom of the vessel in form of a very shining yellow citron-colored powder. This yellow mercurial powder, having been well washed, is called *turbith-mineral*, and is a very powerful emetic.

The water with which it is washed contains the acid that was united with the mercury; but it also contains a little mercury, that remains in a saline state, and is soluble in water, by means of the very large quantity of acid.

Most chemists, especially Mr. Rouelle, have believed that a portion of vitriolic acid remains united with the turbith mineral, but too little to render it soluble in water. On the contrary, Mr. Beaumé, having examined this matter, affirms that turbith mineral contains no acid, when it has been sufficiently washed; and that by frequently boiling this preparation in a large quantity of distilled water, not a vestige of acid will adhere to it.

Turbith mineral may also be made, by precipitating mercury from its solution in nitrous acid by means of vitriolic acid, or of some vitriolic salt. For this purpose the nitrous acid must be well saturated with mercury: for if it contains any unsaturated acid, no turbith mineral will appear upon adding either vitriolic salts or pure vitriolic acid. Hence mistakes may be committed in making experiments to discover the presence of vitriolic acid by means of a solution of mercury, as is frequently done.

We ought also to observe, that turbith mineral becomes yellow only by being deprived of the adhering vitriolic acid, and that it remains white till it has been washed with a large quantity of water; in general, the more perfectly it is deprived of acid, the deeper yellow color it acquires.

Turbith mineral has been formerly celebrated for the cure of the venereal disease, but it is now little used, because preferable mercurial remedies have been discovered. See ACID (VITRIOLIC), and MERCURY.

#### DCCVII. TURPENTINE. (1)

(1) TURPENTINE is a resinous juice extracted from several trees. Sixteen ounces of Venice turpentine being distilled with water, yielded four ounces and three drams of essential oil; and the same quantity distilled

without water, yielded with the heat of a water-bath, two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is further continued, it acquires



## DCCVIII. T U T E N A G. (m)

a reddish brown color. In the first state it is called boiled turpentine, and in the second, colophony or common resin. On distilling sixteen ounces in a retort with an open fire encreased by degrees, we obtain, first, four ounces of a limpid colorless oil, then two ounces and two drams of a thicker yellow oil; and lastly, two ounces and a dram of a dark-brownish red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The *essential oil* commonly called *spirit of turpentine* cannot without singular difficulty be dissolved in spirit of wine, though turpentine itself is easily soluble in that spirit.

One part of the oil may be dissolved in seven parts of rectified spirit of wine; but on standing a while, the greatest part of the oil separates and falls to the bottom. *Neuman.*

(m) TUTENAG. This name is given in India to the semi metal *zinc*. It is also sometimes applied to denote a white metallic compound brought from China, called also *Chinese copper*, the art of making which is not known in Europe. It is the best imitation of silver which has been made. It is very tough, strong, malleable, may be easily cast, hammered and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is.

## V.

DCCIX. **V** A L E R I A N. (n)DCCX. **V** E N U S is the name of a planet, which chemists have also applied to signify copper.DCCXI. **V** E R D I G R I S E. Verdigrise is copper corroded and reduced to a very beautiful green rust, by a vinous acid. This matter, which is very useful to painters, is conveniently manufactured at Montpellier; the wines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following process for making verdigrise is described by Mr. Monet of the Royal Society of Montpellier, and is published among the Memoirs of the Academy for the years 1750 and 1753.

Vine-stalks well dried in the sun are steeped during eight days in strong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in summer is finished in seven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is sufficiently advanced, which may be known by observing the inner surface of the lids of the pots, which during the progress of the fermentation is continually wetted by the moisture of the rising vapors, the stalks are then to be taken out of the pots. These stalks are by this method impregnated with all the acid of the wine, and the remaining

(n) VALERIAN. An ounce of the dry root of valerian yielded with rectified spirit of wine three drams and six grains of resinous extract, and the same quantity with water yielded four drams and twenty-one grains. The distilled spirit is slightly, and the distilled water is strongly impregnated with the smell of the valerian, but no separable oil is obtained. The most active preparation is the spirituous extract, which contains all the useful matter of the root. *Neuman.*

liquor

liquor is but a very weak vinegar. The stalks are to be drained during some time in baskets, and layers of them are to be put into earthen pots with plates of Swedish copper, so disposed that each plate shall rest upon and be covered with layers of stalks. The pots are to be covered with lids, and the copper is thus left exposed to the action of the vinegar, during three or four days or more, in which time the plates become covered with verdigrise. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moistened with water, or with the weak vinegar above-mentioned, and left to dry. When this moistening and drying of the plates has been thrice repeated, the verdigrise will be found to have considerably encreased in quantity, and it may then be scraped off for sale.

A solution or erosion of copper, and consequently a verdigrise, may be prepared by employing ordinary vinegar, instead of wine, as is directed in the above process. But it would not have the unctuousity of ordinary verdigrise, which quality is necessary in painting. Good verdigrise must be prepared by means of a vinous acid, or solvent, half acid, and half spirituous. Accordingly, the success of the operation depends chiefly on the degree of fermentation to which the wine employed has been carried: for this fermentation must not have been so far advanced that no sensibly vinous or spirituous part remained in the liquor.

Verdigrise is used for painting, as it furnishes a fine green color, when mixed with oil. It enters also as an ingredient into several plaisters and ointments. In Chemistry, verdigrise is used for the extraction of radical vinegar, and for the preparation of *crystals of verdigrise*, or of *Venus*. See CRYSTALS of VENUS, COPPER, and VINEGAR.

#### DCCXII. VERDITER (o).

DCCXIII. VESSELS (CHEMICAL) and UTENSILS. We have shewn at the article LABORATORY, how a chemical laboratory ought to be disposed, and the principal utensils with which it ought to be furnished. At the article FURNACES, we have mentioned whatever is essential to be known concerning those instruments. Lastly, we have described under each particular name, the principal vessels employed in chemical operations. Nothing therefore remains but to make here a kind of enumeration, useful to those who would furnish a laboratory; which enumeration may be considered as a compleat supplement to that which is given at the article LABORATORY.

(o) VERDITER is a blue pigment obtained by adding chalk or whiting to the solution of copper in aqua fortis. It is prepared by refiners of silver, who employ for this purpose the solution of copper, which they obtain, in the process of parting, by precipitating silver from aqua fortis with plates of copper. See PARTING. It is said that a fine coloured verditer cannot be obtained from a solution of copper prepared by dissolving directly that metal in aqua fortis; and that the silver is necessary. We know that it is actually made by the refiners only. Dr. Merret says that it is prepared in the following manner: a quantity of whiting is put into a tub, and upon this the solution of copper is poured. This mixture is to be stirred every day for some hours together till the liquor loses its color. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper color. Then it is to be spread on large pieces of chalk, and dried in the sun.

The

The ancient chemists, and especially the alchemists, have invented vessels of many various kinds and whimsical shapes, suited to their several operations. But now the number and variety of those vessels are much diminished, either because modern chemists have not so much patience for such tedious and perplexed operations as the alchemists had, or because they have found that their operations can be performed with vessels of a simpler form, and less various. Accordingly the vessels required in a laboratory are few and simple, which is certainly an advantage. The chief of these vessels are,

*Copper Alembics*, with their *refrigeraries*, *worms*, and *receivers*. See all these words, and PLATE I.

*Alembics of Glass*, of *Stone*, and *Earthen-Ware*, of different sizes, with their *receivers*, which are matrasses with longer or shorter necks. See PLATE I.

*Adapters*, which are small receivers with two necks, the use of which to encrease the distance of the receiver from the distilling vessel and the furnace.

*Aludels of Earthen Ware*. See PLATE I.

*A Balance*. See this word.

*Balloons*, which are matrasses with large bellies and short necks. They are used as receivers. See BALLOONS.

*Bottles* of all kinds and sizes. A great number of these is required in laboratories, to contain the different liquors, and substances that are volatile, deliquescent, or corrosive. The most necessary of these are large glass bottles containing three, four, six pints, or more, of any form, for containing those matters that are used in large quantities. *Crystal-glass Bottles* with glass stopples, to contain all volatile or corrosive liquors. The small bottles or *Phials* are very convenient, and may be used as matrasses in many small operations. See MATRASS.

*Glass Jars* are cylindrical vessels useful for containing many dry and not volatile substances. Their mouths are generally closed with cork or with paper. Large jars are convenient for the mixing of liquors, for precipitations, &c. A great number of these is required of different sizes.

*Basins* of metal. These are useful for evaporations. They are generally of copper; but as this metal is very liable to be corroded by saline matters, a silver basin is very convenient.

*Capsules*, or *Dishes* of glass, of stone-ware, and of crystal-glass, which are the best of any. These are used in the evaporations of corrosive matter capable of acting upon metals. Some also are made of crucible-earth, and of plate iron, which are employed for containing the sand of sand-baths.

The *Cone*. This is a cast-iron vessel of the form of a hollow cone, to the point of which is fixed a pedestal, that it may stand firmly, with its point turned downwards. The use of this cone is to receive metallic matters melted with other substances, all which being poured into it, the metallic parts of the mixture sink by their weight to the point of the inverted cone, and are there collected in form of a *regulus*. The cone ought to be heated, and greased with tallow, before the melted matters are poured into it.

*Retorts*. See that word.

*Crucibles* are kinds of earthen pots of a cylindrical, conical, or triangular figure, used for fusions of all kinds. They ought to be covered with lids. See POTTERY.

*Glass*

*Glass Funnels.* These ought to be of various sizes; and are necessary for small filtrations, and for the pouring of liquors into bottles.

*Ingot-moulds* are iron vessels of a certain thickness, of the form of hollow semi-cylinders, to which a handle is annexed. The surface of their semi-cylindrical cavities ought to be very smooth. They are of various sizes. The use of these vessels is to receive melted metals into their cavities, the form of which is given to the metals, which are then called *ingots*. We ought always to heat and to grease these moulds before the melted metal is poured into them. See PLATE I. Fig. II.

*Mortars.* See that word.

*Matrasses* are long-necked bottles. Some of these have round, and some flat bottoms. Some are shaped like an egg, and thence are called *philosophic eggs*. Matrasses are used for *solutions and digestions*.

*Muffles.* These vessels, which ought to be made of crucible earth, have the form of a hollow cylinder divided in the direction of its axis, and closed on all sides, excepting its front. This vessel represents an oblong arch or vault, the hinder part of which is closed by a semicircular plane, and the lower part or floor of which is a rectangular plane. It is a little oven that is placed horizontally in essay and enamelling furnaces, so that its open side corresponds with the door of the fire-place of the furnace. Under this arched oven small cupels or crucibles are placed; and the substances contained are thus exposed to heat without contact of fuel, smoke, or ashes. See FURNACE (ESSAY); PLATE I. Fig. 9, and PLATE II. Fig. 1.

*Pelicans.* See that word, and PLATE I. Fig. 6.

*Receivers.* See that word, and PLATES I. and II.

*Circulatory Vessels.* Two matrasses are so called, into the largest of which the matter to be operated upon is to be introduced, and the neck of the smaller matrafs is to be fitted into the neck of the former, so as to be a kind of stopple to it. The joining is to be closed with a lute suitable to the vapors intended to circulate. By means of this apparatus, one or more substances may be digested during a long time without any evaporation, because the vapors which rise are condensed in the small matrafs that serves as a stopple, and continually fall back upon the matter in the great matrafs. It is, as we see, a very simple apparatus, which produces the same effect as the pelican.

*Subliming Vessels.* This name was formerly given to a long-necked matrafs, which being covered with a capital, formed a kind of alembic. It was employed in the distillation and rectification of very volatile substances; but since we have found that the length of the neck of an alembic is quite useless, these have been quite abandoned. Accordingly, the true subliming vessels are those that are actually employed in sublimations. See ALEMBICS, ALUDELS, MATRASS, and SUBLIMATION.

DCCXIV. V I N E G A R. Vinegar is a vegetable spirituous acid, produced by the second degree of fermentation, or by that fermentation which succeeds the spirituous, and is called the *acid* or *acetous fermentation*.

From this definition it appears, that wine only or vinous liquors can be changed into true vinegar. Every liquor which has completely undergone the spirituous fermentation, is spontaneously and necessarily disposed to the acid fermentation. Accordingly every wine does continually tend to become vinegar, and

and actually is changed into vinegar, sooner or later, according to circumstances; unless this change be prevented by some obstacle to fermentation in general. Vinegar may therefore be made not only from wine of grapes, but also from cyder, beer, and, in a word, from all other wines. But as the wine of grapes is preferable for this purpose, we shall describe the method of converting it into vinegar.

As vinegar is produced by a fermentation, its qualities depend much on the method of exciting and of conducting that fermentation. The wine which is generally converted into vinegar, and which for its cheapness is generally employed for this purpose, is such as has already become sour; although the better and the more spirituous the wine is, and also the more of the vinous spirit that can be retained in the vinegar, the better and stronger this will be. Beccher says, in his *Physica Subterranea*, that having digested wine in order to convert it into vinegar in a bottle hermetically sealed, he found, that although a longer than the ordinary time was required, the vinegar produced was much stronger than when free air is admitted. Mr. Cartheuser also affirms, that the strength of vinegar may be much increased by adding some aqua vitæ to the wine before it is exposed to the acetous fermentation.

Different methods are practised by manufacturers for making vinegar, who are generally believed to be possessed of some secret for that purpose. Nevertheless no more seems requisite in the preparation of good vinegar, than to employ good wine, and to conduct the fermentation in the most advantageous method; in the same manner as good wine can only be made from good must, and by a well conducted fermentation. The principal part of these operations is performed by nature.

The method of making vinegar consists in mixing the wine to be fermented with its dregs, and its tartar, and in exposing this liquor to a heat of about eighteen or twenty degrees. This fermentation seems to require more heat than the spirituous. It also excites more heat and tumult; and although it ought to be allowed to proceed briskly, yet it is necessary from time to time to check it.

Boerhaave describes, in his *Elements of Chemistry*, the following process, which seems to be well contrived, for the making of vinegar.

Take two large oaken vats or hogsheds, and in each of these place a wooden grate or hurdle, at the distance of a foot from the bottom. Set the vessel upright, and on the grate place a moderately close layer of green twigs, or fresh cuttings of the vine. Then fill up the vessel with the footstalks of grapes, commonly called the *rape*, to within a foot of the top of the vessel, which must be left quite open.

Having thus prepared the two vessels, pour into them the wine to be converted into vinegar, so as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled vessel with liquor from that which is quite full, and which will now in its turn be left only half-full. Four-and-twenty hours afterwards repeat the same operation, and thus go on, keeping the vessels alternately full and half-full during every twenty-four hours, till the vinegar be made. On the second or third day there will arise, in the half-filled vessel, a fermentative motion, accompanied with a sensible heat, which will gradually increase from day to day. On the

the contrary, the fermenting motion is almost imperceptible in the full vessel, and as the two vessels are alternately full and half-full, the fermentation is by that means, in some measure, interrupted, and is only renewed every other day in each vessel.

When this motion appears to have entirely ceased, even in the half-filled vessel, it is a sign that the fermentation is finished; and therefore the vinegar is then to be put into casks close stopped, and kept in a cool place.

A greater or less degree of warmth accelerates or checks this, as well as the spirituous fermentation. In France it is finished in about fifteen days, during the summer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Mr. Reaumur's Thermometer, the half-filled vessel must be filled up every twelve hours; because if the fermentation be not so checked in that time, it will become violent, and the liquor will be so heated, that many of the spirituous parts, on which the strength of the vinegar depends, will be dissipated; so that nothing will remain, after the fermentation, but a vapid liquor, sour indeed, but effete. The better to prevent the dissipation of the spirituous parts, it is a proper and usual precaution to close the mouth of the half-filled vessel, in which the liquor ferments, with a cover made also of oak-wood. As to the full vessel, it is always left open, that the air may act freely on the liquor it contains: for it is not liable to the same inconveniencies, because it ferments but very slowly.

In the *Dictionnaire Portatif des Arts et Metiers*, another method is described, by which a very good vinegar is commonly made at Paris from the lees of wine. For this purpose all the wine contained in the lees is pressed out, and put into large casks, the bung-holes of which are left open. These casks are put into a hot place; and if the fermentation proceeds too fast, it must be checked by adding more fresh wine. This process is very similar to the foregoing.

The appearances which accompany the acetous fermentation resemble much those that occur in the spirituous fermentation. In both fermentations, an intestine motion, a swelling, a hissing noise, and an ebullition, may be perceived. There are nevertheless essential differences between them. Besides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is scarcely sensible, while that produced by the latter is considerable. Secondly, we have reason to believe, that the vapour which exhales from vinegar during fermentation is not noxious, as the vapor of fermenting wine is; at least, it has not been observed to produce such bad effects. On the contrary, as the acid of vinegar more and more disengages or unfolds itself, it seems to acquire more power to bind and retain the inflammable principle, which is the truly dangerous part of these vapors. Lastly, vinegar does not deposit tartar as wine does, even although it has been made with wine that had not deposited its tartar. But the sediment of vinegar is a viscid, oily, and very putrescent matter. The grape-stalks used in the making of vinegar, to promote and encrease the fermentation, are covered over with this matter during the operation. They are generally washed clean, and carefully preserved, to promote the fermentation of more vinegar; because the acid with which they are soaked acts powerfully as a leaven or ferment. The casks also which have been used for the preparation of vinegar are to be cleaned

from the above-mentioned viscid matter, and kept for the same use, as they are rendered fitter than new casks for the preparation of vinegar.

When the acetous fermentation is finished, the nature and the character of the liquor that has undergone it are totally changed. Wine has a taste and smell, partly spirituous, somewhat acid; but in good wine the spirit so much prevails over the acid, that the latter is scarcely perceptible. The taste and smell of vinegar also is partly acid and partly spirituous; but the former quality so entirely prevails, that the latter is almost totally concealed.

We cannot form any very clear and distinct knowledge of the manner in which Nature performs these changes in fermenting liquors. The properties of wine and vinegar prove, that the acetous fermentation unfolds in a very singular manner the acid parts of wine, and intimately combines them with the inflammable spirit. Hence, by changing wine into vinegar, its ardent spirit is so covered by the large quantity of acid, that it is no longer perceptible; that it now cannot affect the head and intoxicate; and that if it be distilled, the first liquor that rises with a heat less than that of boiling water is not an ardent spirit, as when wine is distilled, unless the vinegar be too new, and the acetous fermentation has not been completely finished; in which case the vinegar yields a little ardent spirit: but when old vinegar is distilled, the liquor that rises first is a slightly acid phlegm, which contains the most volatile, the most odoriferous, and the most spirituous part of the vinegar.

The acid of vinegar is employed in many chemical and pharmaceutical preparations, for which not common vinegar, but the acid spirituous part of vinegar that is obtained by distillation, called *distilled vinegar*, is chiefly employed.

The process of distilling vinegar is very simple. A quantity of good ordinary vinegar is put into a large cucurbit or still, which ought to be made of stone-ware, and not of metal, as the acid of vinegar is capable of acting upon most metals. This cucurbit is sunk in a deep furnace, so that five or six fingers breadth only near its neck appears. The neck is to be carefully luted with clay all round the furnace, that the capital may not be heated too much. A capital and a glass receiver are then to be fitted, and the distillation is to be begun, with a very gentle heat. The acid spirituous liquor passes by drops into the receiver. This liquor is white, transparent, penetrating, somewhat empyreumatic, and disengaged from an acid, but not spirituous substance, and also from an extractive saponaceous matter, both which are contained in ordinary vinegar. These latter substances remain in the still with the coloring matter, and form together an extremely acid extract of vinegar. This residuum contains also some tartar, and by incineration yields much fixed alkali, as all matters belonging to vines, grapes, or wine, do.

We should be much mistaken if we believed that the acid spirituous portion of the vinegar that rises in this distillation, is a stronger acid than the vinegar itself. Vinegar is not distilled with an intention to concentrate it, but only to disengage it, as we have said, from its extractive part. The acid which this part contains is not, properly speaking, vinegar, but is oily, not spirituous, less volatile than the former, or even than water. Accordingly, the acid obtained in this distillation, when well conducted, is more spirituous and also more watery than the acid of the residuum.



Chemists have attempted different methods of concentrating distilled vinegar. Stahl has taught us the best method for depriving it of its water without any alteration. This method consists in exposing it to a cold sufficiently intense to freeze its watery part, which is afterwards separated in lumps of ice from the more acid part. Thus the acid of vinegar may be considerably concentrated. See the CONCENTRATION of VINEGAR by FROST.

The acid of vinegar may be more effectually concentrated by combining it with alkalis, earths, and metals, as any other acid may. Thus by drying perfectly neutral acetous salts with fixed bases, and afterwards by decomposing them, either by the mere action of the fire, or by means of concentrated vitriolic acid, we obtain the strongest acetous acid that can be produced. This acid is called *radical vinegar*. See SPIRIT of VENUS.

The acid of vinegar dissolves all substances upon which other acids can act, and forms with them neutral salts, some of which have particular names, but which all might be called *acetous salts*.

With calcareous earth this acid forms salts that in crystallizing shoot into silky ramifications and vegetations. These salts are named from their earthy bases, *salt of chalk*, *salt of crabs-eyes*, &c.

With fixed vegetable alkali it forms a very pungent and very deliquescent salt, called *regenerated tartar*, or *terra foliata tartari*. See TERRA FOLIATA.

With fixed mineral alkali it forms a neutral crystallizable salt.

With volatile alkali it forms an *acetous ammoniacal salt*, called *spirit of Mindererus*.

All the combinations of the acetous acid with metallic substances have not been yet examined. The combinations of this acid with lead and with copper are best known, because they furnish several preparations used in painting, and some other arts. This acid united with copper forms *verdigrise* and *crystals of Venus*; and with lead forms *ceruse*, and *salt or sugar of lead*. See these several articles. The vinegar in which lead is dissolved is called *vinegar of lead*, and is sometimes used as a cosmetic, for repelling cutaneous eruptions. But this cosmetic ought not to be employed but under the direction of a prudent physician, as it may occasion a dangerous translocation of the morbid humour to other parts.

Mercury dissolved first by nitrous acid, and afterwards precipitated by fixed alkali, is quickly soluble in vinegar, with which it forms a mercurial acetous salt. The crystals of this salt are shining silver-like plates, not very soluble in water. See MERCURY.

Vinegar very much concentrated, as the rectified spirit of Venus, or radical vinegar, being distilled with equal parts of highly rectified spirit of wine, furnishes a liquor which has all the essential characters of ether, or rather is a true ether, called *acetous ether*. The discovery of this ether was lately made by the Count de Lauraguais. See ETHER (ACETOUS).

Vinegar being an oily, spirituous, vegetable acid is much weaker than mineral acids, which are less compounded. Accordingly all acetous neutral salts may be decomposed by any mineral acids, excepting the vitriolic acid when very much sulphurated, which cannot be considered as a pure acid.

According to Mr. Gellert's table, the affinities of the acetous acid are in the following order: Inflammable principle, zinc, iron, copper, lead, and bismuth.

Gold, silver, tin, and mercury, are marked in this table as incapable of uniting with this acid.

Vinegar is very useful, not only in ordinary life as an agreeable seasoning for many kinds of food, but also in medicine, in chemistry, and in several arts.

This acid is in general antiseptic, and is considered as incisive and aperitive. It is used as a vehicle in many preparations which possess these qualities. Thus *simple oxymel* is a syrup made of honey and vinegar. Such also are *oxymel of squills*, and several other compound vinegars for the use not only of medicine, but also of the toilette; receipts for all which are found in dispensatories. A very important medicinal virtue has been attributed to vinegar, namely, that of curing the canine madness. Mr. Buchoz, in a work entitled, *An Historical Treatise of Plants growing in Lorraine and the Three Bishopricks*, affirms, that several successful trials have ascertained the efficacy of vinegar against the ill effects arising from the bite of mad dogs, when it is given in the quantity of a pound each day, divided into three doses; one to be taken in the morning, another at noon, and the third in the evening. The discovery of this quality of vinegar was made accidentally at Udina, in Trioul, a province belonging to Venice, by an inhabitant of that town, who having been seized with canine madness, was cured by drinking a glass of vinegar by mistake, instead of some medicine that had been prepared for him.

We have already mentioned the use of vinegar in several chemical preparations, particularly of cerufs and of verdigrise.

DCCXV. VINEGAR (DISTILLED). This is the spirituous acid of vinegar obtained by distillation. *See the preceding article.*

DCCXVI. VINEGAR (RADICAL). *See SPIRIT of VENUS.*

DCCXVII. VINEGAR of LEAD. Is a solution of lead or of cerufs in distilled vinegar. *See the articles LEAD and VINEGAR.*

DCCXVIII. VITRIFICATION. Vitrication is one of the most curious and most important operations in chemistry. The product of this operation is Glass; a matter which, when well made, is valuable for its great hardness, beauty, and perfect transparency. These principal and essential qualities of glass render it very extensively useful in ordinary life, in natural philosophy, in chemistry, and in many arts. Almost any form may be given to glass, and all kinds of vessels and utensils may be formed of it, which are capable of resisting the most powerful corrosives and solvents. Glass is capable of receiving and preserving the finest polish. Its properties of transmitting and refracting the rays of light, and of reflecting these rays when one of its surfaces is covered with a metallic coat, render it very useful for constructing mirrors, telescopes, microscopes, and all kinds of optical glasses; for collecting, separating, and decomposing the rays of light; and for exhibiting many wonderful catoptrical and dioptrical appearances and experiments. If to these admirable properties we add that of imitating the many brilliant precious stones, opake or transparent, we shall easily be convinced that perfect glass is one of the most beautiful and excellent productions of human industry.

The art of making glass is dependant on chemistry in all its parts. In its principles it is simple, but extensive in its detail, and difficult in its practice. The extent of this art does not permit us to enter into the particulars, or into

its

its several branches. In this article we shall only endeavor to explain the chemical principles upon which the art depends, and which may direct experimental philosophers as well as intelligent artists in their researches to improve it.

Perfect glass, or the most beautiful factitious crystal, is perfectly similar in appearance to the whitest and most transparent natural vitrifiable stones. The only sensible difference between these natural and artificial productions is, that the latter are much less hard and more fusible than natural crystal, or any other vitrifiable stone. In fact, pure glass or artificial crystal is essentially of the same nature as vitrifiable stones; or we may rather say, that it is vitrifiable earth itself rendered more fusible only by certain additions, as we shall soon shew.

The most simple and elementary of all earths, called by chemists *vitrifiable earth*, forms the hardest and most transparent of all natural bodies, when its integrant parts are united together in a due state of aggregation: but the parts of vitrifiable earth cannot form this aggregation, unless they have been previously so much separated from each other, that they possess a mobility which enables them to unite together according to their natural tendency: the integrant parts of elementary earth may acquire this mobility by two methods; namely, by the interposition of the parts of water, or of those of fire.

Almost all the vitrifiable stones that we know, as diamonds, rock-crystal, and other hard transparent stones, appear to have been once dispersed in infinitely small molecules through much water, from which they have afterwards been deposited, and then have united together and formed the very hard transparent masses which we now see. The regular and uniform crystallization of these precious stones is an evident proof of this truth.

Possibly some of these stones may have been formed by fire, and by a true fusion. Perhaps even this terrestrial globe has been once, as Mr. de Buffon thinks, one sphere of melted glass, or one immense diamond, the outer crust of which only has been changed by the elements; while the interior parts still remain in their vitrified state (*p*): but we certainly know, that of the two above-mentioned methods by which pure solid masses of vitrifiable earth may be formed, that of the division and elaboration by water cannot be practised by human art, on account of the many ages required for the operation.

By the second method, namely, *fusion*, the time required for which is better adapted to the shortness of our lives, we certainly might, with a sufficient degree of heat, melt vitrifiable earth, and all other kinds of earths; since these, when sufficiently purified, are reduced to the nature of vitrifiable earth; and we might convert these earths into masses of crystal, or of hard transparent stones,

(*p*) Mr. Buffon conjectures, that the earth, as also the other planets, might have been parts knocked off from the sun by a comet falling upon its surface; that they received from the impulse of the comet their progressive motion; and also, by the obliquity of the stroke, their motion round their own axes; that the earth was then in a vitrified

and fluid state; and that a vapor exhaled from its surface by the violent heat, the grosser parts of which, being afterwards condensed, formed water, and the less dense remaining suspended formed air. We have not heard that many philosophers have adopted this theory of the formation of the planets.

as perfect as the natural precious stones. In a word, nothing but a heat sufficiently intense is required to melt any earthy matter, and to convert it into a diamond, as brilliant and as hard as the most perfect natural diamonds: but here a great, and hitherto unsurmountable difficulty occurs, namely, to produce a heat sufficiently intense to melt the most pure and simple vitrifiable earth; for the most violent heat that art has ever produced is insufficient to melt even many of the common impure earths and stones, and is therefore much less capable of melting that earth, which, because it is the simplest and purest, is also the most unfusible of all natural bodies. See EARTH.

Hence we conclude, that although we know by what means the parts of the purest earthy principle may be so united as to form bodies similar to the natural precious stones, yet we cannot possibly put these means in execution: but if we cannot artificially produce solid masses of pure earth exactly similar in all their properties to the natural precious stones, we can however very well imitate these beautiful natural productions, not in their hardness and unfusibility, but in their transparency and lustre; that is, in their most obvious and striking qualities, by means of compositions of glass or facitious crystal. The solution of this problem is founded on the following principles.

First, pure and elementary earth, which makes the principal basis of all vitrifications, and therefore called vitrifiable earth, is indeed unfusible with regard to us: but we know, that certain very fusible substances are capable of uniting intimately with this earth, and of communicating to it some of their fusibility; so that by their means we may reduce it to a perfect fusion.

Secondly, the substances capable of acting upon the earthy principle are the inflammable principle or phlogiston, and several saline matters: but we may remark, that as these substances do only act as fluxes by uniting intimately with the vitrifiable earth, and while they themselves make part of the glass; and also, as the integrant parts of these fluxes are not capable of forming either with each other, or with the parts of vitrifiable earth, so strong an adhesion as that which can be formed between the parts of the pure vitrifiable earth; it follows, that all facitious crystal must be much less hard than natural crystals, or other hard stones; since these contain only pure vitrifiable earth.

Thirdly, in consequence of the principle, that all compound bodies partake of the properties of their component parts, facitious crystals ought to partake so much more of the properties of inflammable and saline matters, and ought to be removed so much more from those of pure vitrifiable stones, as they contain a larger quantity of those matters. Accordingly we find, that the smaller quantity of flux that is contained in glass, the greater hardness, lustre, and resemblance to natural stones it has, provided the fusion has been complete. Thus glass is so much more perfect, as it possesses more of the properties of vitrifiable earth.

These principles, which are incontestable, being once understood, are easily applicable to the art of making glass, as we shall shew: since, if we could produce a fire sufficiently intense, and had furnaces and vessels capable of sustaining it, we should make glass equal to the precious stones; it is therefore evident, that the most important object in vitrification is to have furnaces capable of producing the greatest heat, and pots or crucibles capable of resist-

ing, during a long time, this heat, and also the action of the vitrescent matter that they contain. At the articles of this Dictionary, CLAY and POTTERY, may be seen what are the best earths, or mixtures of earths, for the construction of furnaces, and of pots or crucibles. We shall here only repeat, that these pots ought to be made entirely of the most refractory and purest clay, well washed and cleansed from all sandy, ferruginous, and pyritous matters, and mixed with a certain proportion of the same clay baked, and pounded not very finely. The quantity of baked clay that ought to be mixed with the crude clay, to prevent the pots from cracking when dried, or when exposed to violent heat, is not absolutely determined, but varies in different glass-houses, according as the crude clay employed be more or less fat, as it is called : but Mr. D'Antic, Doctor of Physic, a very able chemist, and particularly conversant about every thing relating to the theory and practice of glass-making, in an excellent Memoir upon this subject, proposes a very good method of ascertaining the quantity of burnt clay that ought to be mixed with crude clay in the composition for pots and furnaces. - This method consists in mixing the burnt and crude clay in different proportions, and in forming cakes of these several mixtures, each of which is one inch in thickness, and four inches in each of the other two dimensions. When these cakes have been sufficiently and very slowly dried, and are exposed to a violent heat, till they become as hard, and contract as much in their dimensions as they can, they are to be then examined ; and the cake which has suffered a diminution of its bulk equal only to an eighteenth part is made of the best proportions. According to the same author, most clays require that the proportion of the burnt should be to the fresh as four to five.

The ovens and furnaces are different according to the quantity of materials to be vitrified. For experiments and essays, we know none better than the melting furnace described at the article FURNACE, and which must be heated with charcoal. In large works wood or fossil coal are used, and the furnaces are so constructed that the flame of the fuel circulates and burns within very intensely. As these furnaces vary much in different countries and glass-houses, and as a description would not be very intelligible without figures, we shall refer the reader to other works in which these several furnaces are described and represented, particularly to the French edition of Neri's Art of Making Glass, with Notes by Meßner and by Kunckel, and to the above quoted Memoir of Mr. D'Antic. We shall here say only in general, that these furnaces are placed under large and lofty buildings called *halls* ; that they are covered with a vaulted roof ; and that they have no chimney, but only lateral openings through which the melted glass is drawn from the pots. Under these openings is built a kind of platform or banquette, on which the pots containing the glass stand, one of which is opposite to each opening. In the middle of the furnace, below the banquette, is a space, a-cross which iron bars are laid. In this space, which communicates with a large cavity below, called the ash-hole, the fuel is placed. In these furnaces, which have not any chimney, as we have said, the fire is nevertheless very intense. This intense heat is occasioned by the great capacity of the furnace, by means of which a strong draught of air passes continually from the ash-hole. Besides, the flame, being vividly agitated by air, and not being drawn out of the furnace by any chimney, circulates in every

every direction within the furnace, and produces a very violent heat. Most glass-house furnaces have also hollow towers that communicate with the cavity of the furnace, and which therefore encrease the capacity of the whole. In these the heat is not nearly so intense as in the furnace. They are employed to contain the *fritt*, or the pieces of manufactured glass that are to be annealed. Such is the general disposition of the furnaces of glass-houses.

The good condition of the pots and furnaces is, as we have observed, the most important and essential matter to be considered in the operations of making glass. Next to that, is the consideration of the kinds and proportion of the fluxes. Of these we may observe two kinds, namely, the inflammable and the saline. As we cannot obtain the pure inflammable principle, we must, when we intend that it should enter into the composition of glass, chuse for this purpose some of the earthy substances with which it is found naturally combined; and these are particularly metallic earths, which are best adapted for conveying phlogiston into vitreous compositions: but all these earths are not equally fit for this purpose. All metals are composed of an earthy matter intimately combined with a sufficient quantity of the inflammable principle to be very fusible, and, at the same time, very opaque. Some of these metals, namely, those called *perfect*, are unalterable by fire, and cannot be entirely, or even partly, deprived of phlogiston: but as every metallic substance is incapable of uniting with earthy matters, while it retains its metallic state, therefore no perfect metal can be vitrified. The case is different with those metallic substances, the phlogiston of which may be burnt, or otherwise destroyed. The earths or calxes of most, perhaps of all combustible metals, when not perfectly deprived of all their phlogiston, are capable of being reduced to a vitreous state, by means of their remaining inflammable principle. As they are not then in a metallic state, they can facilitate the fusion of vitrifiable earths, may contract with these an intimate union, and reduce them to a state of perfect vitrification: but these phlogisticated calxes of imperfect metals promote vitrification more or less, according to their particular natures. Some of these, as, for instance, tin, cannot be without great difficulty brought to that precise degree of calcination that is necessary to vitrification; because the heat required for this purpose deprives them of all their phlogiston, and renders them in a high degree refractory. Others, in whatever manner they be calcined, either retain too little phlogiston to be sufficiently fusible, although they still retain enough to give them color; or if they be not calcined so much as to lose their fusibility, they cannot be melted but into opaque masses, so nearly in a metallic state that they cannot be united intimately with vitrifiable earths. Such, especially, are the earths of iron and of copper.

Of all metallic earths, that of lead is fittest for vitrification. This metal, which contains a large portion of phlogiston, is quickly deprived of so much of it, that it loses its metallic state, and is easily melted into a transparent vitreous mass; but it has, at the same time, this remarkable property, that when once it has lost as much phlogiston as is necessary to dispose it to vitrification, its calx strongly retains as much of it as is necessary to give to it its greatest degree of vitrescibility; and that it may be sooner dissipated into vapors by the continued action of a very intense fire, than it can be changed into an earth  
totally

totally dephlogisticated, and consequently refractory, like the calxes of tin and of regulus of antimony. Besides, the fusible earth of lead is one of those that retain the least color. All these qualities render it preferable to any other metallic earth for the purposes of vitrification. The earth of bismuth, which in the above-mentioned properties resembles the earth of lead, may probably be employed with equal success: but as the calxes of lead are much more common than those of bismuth, the use of this semi metal is not known to manufacturers of glass.

In whatever manner the calx of lead has been prepared, provided it be really in a calcined and not in a metallic state, it may be used in vitrification. Accordingly, the grey calx, or ashes of lead, massicot, red lead, litharge, ceruss, and all the precipitates of lead, separated from acids by unmetallic intermediate substances, being mixed with sand or any other vitrifiable stone, and exposed to a sufficient degree of fire, do always promote the fusion of such matters, and form with them glasses more or less hard and transparent, according to the strength of the fire and the proportion of the ingredients.

The earth of lead constantly retains, as we have said, enough of the inflammable principle to preserve its fusibility. When it is exposed singly to the fire, it vitrifies with a very moderate heat. It has more phlogiston than is requisite for its vitrification. The fusibility, fluidity, and activity of this glass of lead, when pure, are so great, that it cannot be contained in any crucible, all which it easily pervades: therefore pure glass of lead is never made. But as the calx of lead has more phlogiston than is required for its own vitrification, it may divide this excess of inflammable principle with any unmetallic earth, and when it is mixed, and thus may produce their fusion and perfect vitrification. The glasses formed by a mixture of calx of lead with unmetallic earths have more consistence, hardness, and less fusibility, than pure glass of lead. The proportions of calx of lead and of sand employed in these kinds of glass are from one part to two of calx of lead, to one of sand, or of ground flints.

We may observe upon the subject of glasses that contain no other flux than phlogiston or metallic earths, of lead, or of any other metal, that none of them are perfectly white, but are all more or less colored; because phlogiston is, as chemists know, the principle of colors. Secondly, these glasses have a greater density or specific gravity than any natural crystalline stone, all metallic earths being heavier than any that are not metallic.

Thirdly, metallic glasses are generally somewhat less brittle, are less liable to be broken by the alterations of heat and cold, and have more of a certain sinoothness, or, as it were, unctuousity, not easily to be described, than glasses made altogether of unmetallic earths. These properties can only be attributed to the inflammable principle; a pretty considerable quantity of which is united with them. As these latter qualities of glass are valuable, a certain quantity of calx of lead generally enters into the composition of most fine glasses, which are distinguished from ordinary glass by the name *crystal-glass*.

From what we have said concerning the properties of metallic earths in vitrification we may perceive, that the more calx of lead, or other metallic earth, enters into the composition of any glass, the more fusible, soft, colored, and

dense this glass is; and reciprocally. The colors given to glass by calxes of lead are shades of yellow.

Saline substances are the second kind of fluxes used in vitrification: but all these substances are not equally fit for this purpose; not that they are not all very fusible, but for several reasons hereafter to be mentioned.

First, neither the pure and disengaged acids, nor volatile alkalis, nor ammoniacal salts can be employed as fluxes in vitrification, because none of these saline matters is sufficiently fixed. Their volatility is so great, that they may be totally dissipated by fire before they could act in any degree upon vitrifiable earth.

Secondly, none of the neutral salts with basis of fixed alkali, containing either vitriolic acid or marine acid, can be employed as fluxes in vitrification. This proceeds, not from their want of fusibility, or of the necessary degree of fixity, but from the union of the acid and the alkali; which, is so strong, that they cannot act with sufficient force upon other substances, and particularly upon vitrifiable earth. The saline matters fit for vitrification are, *fixed alkalis*, vegetable and mineral; *nitres* with basis of fixed alkali; *sedative salt*, and *borax*; *fusible salt of urine*, or rather *phosphoric acid*.

Of all saline matters, fixed alkalis, vegetable and mineral, are most frequently used in vitrification. These alkalis are fusible with a moderate heat; they are so fixed that they can resist during a sufficient time the heat of ordinary vitrifications; and they act powerfully upon flints, sands, and other vitrifiable stones. The proportion of alkali to sand, in order to make good glass, is, from one to two parts of the former ingredient, and two parts of the latter.

Nitre produces in vitrification nearly the same effects as fixed alkalis, altho' it be a neutral salt, the alkali and acid of which are united together nearly as they are in common salt, which however does not produce in vitrification similar effects. The remarkable difference in this respect betwixt these two salts, and betwixt the nitre and the vitriolic salts, must be attributed to the great affinity of nitrous acid to the inflammable principle; which affinity is so strong, that when nitre is exposed to fire in vessels not perfectly close, the acid quits its alkaline basis to unite with the phlogiston of combustible matters, even though these be not sensibly in contact with it. Hence nitre exposed during a certain time to the action of a strong fire, is gradually alkalised, and then becomes capable of dissolving very effectually vitrifiable earth. This alkalisation is produced so much more easily in most vitrifications, that the ingredients employed generally contain some inflammable matter. Common salt cannot be alkalised in this manner, because it cannot be decomposed by the contact of inflammable bodies, and therefore is not used in vitrifications: but as vitriolic acid has a strong affinity with phlogiston, we might be inclined to think, that vitriolic salts with basis of fixed alkali, which also are never used in vitrification, might perhaps be employed along with sand or other vitrifiable matters containing a larger proportion of phlogiston than the ingredients now commonly used do: but I do not know that any sufficiently accurate experiments have been made on this subject.

Fixed alkalis or nitre cannot be formed into transparent glass by being melted singly; because these salts contain too little of the earthy principle; for they  
form



form true glasses when they are mixed with a sufficient quantity of this principle, as with sands and other earthy matters : but borax, sedative salt, and the fusible salt of urine, may be melted without any earthy addition, into transparent vitreous masses ; and hence we may conclude, that these salts contain a larger portion of the earthy principle than nitre or fixed alkali. They nevertheless very powerfully promote the vitrification of other substances. These salts are not employed in the manufacture of large quantities of glass, because they are too dear. Borax is sometimes used for making small quantities of some particular kinds of fine glass.

Arsenic may be enumerated among vitrifying fluxes, as it is fusible and vitrescible singly, and is also capable of promoting the fusion of vitrifiable earths ; for which purpose it is frequently employed as an ingredient in vitreous compositions. As arsenic partakes both of the metallic and saline properties, it probably acts in vitrification both as a salt and as a metallic earth. The quantity therefore of arsenic necessary to promote vitrification, is intermediate betwixt the quantities of calx of lead and of saline substances that are necessary for that purpose. But we must observe, that as arsenic is very volatile, a great part of it escapes in vapors upon the first application of heat, and that the quantity remaining is always uncertain. Arsenic cannot well be employed as the sole flux for vitrifiable earth. When we intend that a certain quantity of this matter should remain in the composition of a glass, one of the best methods that can be used for this purpose, is at the same time to add nitre to the ingredients of this glass ; because the arsenic uniting with the alkaline basis of the nitre forms the neutral arsenical salt, in which the arsenic is considerably fixed. But as this neutral arsenical salt is easily decomposed by contact of phlogiston, therefore no calx of lead or other substance containing the inflammable principle ought to be mixed with arsenic in the composition of glass. I have found by experience that this neutral arsenical salt is very difficultly manageable in vitrifications, not only for the reason now given, but also from the property it has of powerfully corroding and pervading crucibles and pots. In many mixtures I have found that it quitted the vitrifiable earth with which it was mixed, and acted upon the crucible, which it penetrated and dissolved. These experiments induce me to believe, that arsenic has a greater affinity with clays than with vitrifiable earths ; which I propose hereafter to ascertain further.

From Mr. Pott's experiments, chemists know, that vitrifiable, calcareous, and argillaceous earths, each of which are singly unfusible, do reciprocally promote the fusion of each other, when mixed together nearly in equal proportions, and exposed to a very violent heat ; and that from these mixtures matters perfectly vitrified are formed. But as we do not know the cause of this singular fusibility, we cannot determine whether it is produced by a phlogistic or by a saline substance, or perhaps by both.

Glasses that contain no other fluxing ingredient than phlogistic matters or metallic earths, partake of the properties of these metallic earths ; and also glasses that contain only saline fluxes partake of the properties of salts. The latter, or saline glasses, when pure and well proportioned are less heavy, less dense, harder, whiter, more brilliant, more brittle, than the glasses containing calx of lead : and glasses containing both saline and metallic fluxes do also partake of the pro-

erties of both these substances. In general, glasses too saline are soft, and easily susceptible of alteration by the action of air and water; especially those in which alkalis prevail; which latter glasses are also liable to be attacked by acids, as we evidently see from the properties of the vitrified matter that is made with an excess of alkali, for the preparation of *liquor of flints*. Glasses containing too much borax and arsenic, although at first very beautiful, do quickly tarnish and become opaque when exposed to air.

From what we have said concerning the properties of fluxes, phlogistic or saline, we may know how to adjust the proportions of these to the sand, or powdered flints, for the various kinds of glass. Thus if we require a glass that is dense, fusible, and not saline, one part and a half of red lead or litharge may be mixed with one part of sand, and fused together. If equal parts of sand and of calx of lead be employed, a glass somewhat less dense and harder will be produced.

If a glass be required of very little density, only saline fluxes must be employed. A glass of this kind may be composed of six parts of salt of tartar, or of potash, or of purified soda, mixed with eight parts of sand or of flints; or of four parts of any of the above-mentioned alkalis, mixed with two parts of nitre or of borax, and eight parts of vitrifiable earth. These glasses must be left long in the fire for the reasons hereafter to be mentioned.

When a crystal-glass is required which shall be of an intermediate quality betwixt the metallic and saline glasses, it may be made from a mixture of one part of the above-mentioned salts, one part of calx of lead, and two parts of sand or other vitrifiable earth. By varying the proportions of these ingredients, many different kinds of glasses may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to its vitrifying power. Several good receipts for glass, and factitious crystal, may be found in *Neri's Art of Making Glass*, with *Notes by Merret and Kunkel*, to which work we refer for many interesting particulars. We shall however observe, that the proportions of the fluxes necessary to produce any required kind of glass cannot be precisely ascertained, for the following reasons.

First, the sands, flints, and other stones commonly employed for making of glass, are not all equally fusible. Thus the quartzose sand obtained by washing an earth found near Nevers, known to manufacturers of glass and of pottery by the name of *sand of Nevers*, may be almost entirely melted when exposed to a good vitrifying heat; and by a moderate heat its grains may be considerably rounded. I know some other hard stones, which in a violent fire are still more fusible, and convertible into an almost transparent glass without addition. The fusibility of these vitrescible stones is caused by some unknown heterogeneous matter united with them. These fusible sands and stones require much less quantity of flux to promote their vitrification, than other sands or vitrifiable stones, which are much purer, and therefore more refractory.

Secondly, although the phlogistic and saline matters employed as fluxes in vitrification are sufficiently fixed to support the degree of fire necessary for the fusion of glass, they are nevertheless far from being so fixed as vitrifiable earth. The fire necessary for the perfect fusion of glass, is even sufficient to evaporate them entirely. Accordingly in glass-houses where the pots are uncovered, a  
vapor

vapor or smoke continually rises from their surface, which is nothing else than the saline and phlogistic fluxes in a state of continual exhalation. Hence the longer glass remains melted in the fire, the harder and more difficultly soluble it becomes, and the more it partakes of the properties of pure vitrifiable earth. Accordingly, even when a very hard glass is required, such a quantity of flux ought to be added, as shall at first promote a perfect fusion; and this fusion ought to be continued a long time till a considerable quantity of the flux is gradually dissipated, and till the glass has acquired the requisite degree of hardness, provided that the fire be sufficiently strong to maintain the fusion notwithstanding the loss of flux. From these observations it appears, that we cannot precisely ascertain the proportion of flux to vitrifiable earth, unless we knew the fusibility of the sand to be employed, and the degree of heat which can be excited in the furnace.

The saline fluxes, and especially the fixed alkalis employed in vitrification, are generally rendered impure by a mixture of several heterogeneous matters, and especially by neutral salts not vitrifiable, and by a certain quantity of inflammable principle. In manufactories of bottles and other common glass, the alkalis employed are not previously purified, but are even mixed with the earth of the ashes of the burnt plants, which earth is also much disposed to vitrification. Accordingly, to make glass of this kind, sand is mixed with common wood-ashes, sometimes even with those which have been lixiviated, together with some unpurified potash, soda or kelp; and from this mixture a brown, dusky, not very transparent glass is produced, which is preferred in common sale for wine bottles to clearer and more transparent glass. But when a fine, white, and very transparent glass is required, the alkali must be perfectly purified from all heterogeneous matter, by lixiviation and calcination. See the article ALKALI (FIXED).

As a too large quantity of the inflammable principle is the chief cause of the colors and of the opacity of glass, when a perfectly colorless and transparent glass is required, not only the alkalis must be deprived of all their superabundant phlogiston, but also the sands or flints employed must be purified from any of this principle which they may contain. The method used for this purpose is by mixing together the due proportions of sands and salts, by exposing the mixture during a considerable time to a red heat, not intense enough to melt it. By this calcination, the phlogiston of these matters is burnt and dissipated, all color is destroyed, and the glass produced is also more clear and brilliant. This first mixture of materials of glass, when calcined, is called *the fritt*; and this fritt is used in large manufactories not only for the finer glass, but also for the common brown glass; not with an intention to render this latter kind of glass colorless, but because during this calcination, the salts and earths begin to act upon each other, and to incorporate in a certain degree; by which a great part of the effervescence and swelling occasioned by the reaction of these matters, which happen when they are at once exposed to a melting heat, are avoided. Accordingly when matters not previously fritt are employed in small experiments, the heat must be applied gradually; otherwise they will swell, that frequently the greatest part of the mixture runs over the crucible.

The due degree of heat is an essential point in making of glass; it is not only to be very strong, but also maintained during a long time. In order

manufactories, the glass is kept fused during ten or twelve hours before it is taken out of the pots. Accordingly their glass is always more perfect than that which is hastily made in small quantity in two or three hours. Good glass, although kept in fusion in a very great heat, is not perfectly liquid. It is always somewhat thick, and when taken from the crucible, it may be drawn out into fine wire or threads; which shews that it has a certain consistence and a very sensible tenacity when it is red-hot. It is not transparent, while it remains red-hot, not even when it has become perfectly hard. Another remarkable circumstance is, that glass which is so brittle when it is cold and transparent, is very ductile when it is so heated as to be opaque. We might be induced to believe, that the disengaged fire with which the glass is filled when it is red-hot, produces upon it the same effect that phlogiston, or combined fire, produces upon metals. The ductility of red-hot glass is very useful; for by its means all imaginable shapes may be given to glass, and numberless vessels and utensils may be easily formed of it.

As soon as glass-vessels have received their intended form, they must be cooled very gradually, otherwise they would have no solidity, and would be of little use, as they would be liable to be broken by the smallest stroke, or by a slight change of heat and cold. This inconvenience is prevented in glass-houses by carrying the glass vessels as soon as they are formed, and while yet red-hot, into an oven too little heated to destroy their form, but in which they may be very gradually cooled. This is called *annealing* the glass.

Notwithstanding all the care taken in the manufactories of the finer kinds of glass, as crystal-glass and plate-glass, to make them perfectly good, they are nevertheless seldom found quite free from faults. The principal faults in glass are, colors, bubbles, and veins. The colors which generally hurt glass, especially that kind which contains saline fluxes, are shades of green, olive, and blue. These colors are destroyed by *manganese*, which being added in small quantities, clears the glass, and is therefore sometimes called by artists, *the soap of glass*. This effect of manganese cannot easily be explained, for it has the property of tinging glass with a purple color. Mr. Montamy, in his *Traité des Couleurs pour la Peinture en Email*, has a very fine and ingenious thought upon this subject, which is, that the manganese destroys the above-mentioned colors, by adding to these a purple tinge, and by the mixture producing a blackish-brown color; and that as blackness is caused merely by an absorption of the rays of light, therefore the blackish tinge given to the glass by the above mixture of colors, prevents the reflection of so many rays, and thus renders the glass less colored than before. The causes of the bubbles and of the veins in all glass, even when most carefully prepared, and the methods of preventing these faults are little known. No researches have been made upon this subject, by any chemist excepting by Mr. D'Antic, whose experiments are published in the *Memoirs of the Academy*. But however interesting these may be, this matter requires further examination. As the veins of glass, unless they be considerable, are seldom very perceptible in the finer kinds of glass when well compounded, and carefully made, they have therefore been hitherto neglected. Nevertheless we ought to inform those who are interested in the progress of arts and sciences, that since the important discovery of achromatic telescopes has

has been made, the correction of this fault in glass deserves attention. We need only inform those who would attempt this improvement of glass, that the object-glass of these telescopes is composed of several glasses of different degrees of density; and that the effect of this composition of different glasses is (supposing them at the same time to have the due curvatures), that telescopes may be made, which do not exhibit irises when looked through, which are therefore infinitely preferable to ordinary telescopes, and from which astronomy may receive much advancement.

Some great geometers have determined the density and the curvature that these object-glasses ought to have. But in vain have Euler, Clairaut, and D'Alembert illustrated this part of dioptrics by means of the most sublime theory, unless glasses can be made which shall be capable of producing the effects required. No certain and constant method is yet known for making crystal-glasses for this purpose. A celebrated English optician, Mr. Dollond, who has himself had a considerable share in the discovery of these new telescopes, does indeed make them very good (*p*). But our opticians, who procure from England the same glass that is employed by the English opticians, affirm that this glass is very faulty; and that amongst a large quantity, some pieces only can be found fit for the purpose: hence we find that it is not constantly made good in the English glass-houses.

A certain method therefore of making such a crystal glass as is required, still remains to be discovered. Two kinds of glass are required for the object-glass of achromatic telescopes. One of these is a light crystal-glass, made with saline fluxes, like the French mirror-glass.

Good pieces of this kind of glass may be easily found. The other kind of glass is a denser crystal-glass, and therefore contains some calx of lead in its composition. Such is the English flint-glass. The density of this glass ought to be such, that a cubic inch shall weigh fourteen hundred grains. A perfect

(*p*) The indistinctness of the images seen through common telescopes proceeds chiefly from this cause, that some of the colored rays of light are refracted more in passing through glass, or any refracting medium, than the others, and do therefore produce prismatic colors. The late ingenious Mr. Dollond found, that this difference of refrangibility of the colored rays was much greater when the rays passed through some kinds of glass, as crown-glass, than through others, as flint-glass. By adding therefore to the convex object lens of telescopes (which was made of crown-glass) a concave lens made of flint-glass, the curvature of which was not sufficient to destroy the whole convergency of rays of light produced by the convex lens, he counteracted the error proceeding from the different refraction of the colored rays in passing through the convex lens, and, by thus uniting these several rays,

formed one distinct image. This power of different kinds of glass, by which they refract differently the colored rays is not proportionable to the density of the glass; although calx of lead added to glass singularly encreases this difference of refraction. The author of the Dictionary says, that Mr. Dollond had a great share in this discovery. He was the first person who attempted or who executed this improvement. We may indeed observe, that long before, in the year 1713, Dr. David Gregory, the celebrated Professor of Astronomy at Oxford, did suggest, (in his *Catoptrica et Dioptrica Sphærica Elementa*) that by compounding the object lens of a dioptric telescope of several media of different refractive powers, the image might be rendered more distinct, in the same manner (says he) as it is done by the compounded media of the eyes of animals.

glass of this kind cannot be obtained without great difficulty. I have been assisted by some intelligent persons, who have considered this subject of achromatic telescopes, that the qualities essentially requisite in this glass were, that it should be very transparent, and perfectly free from veins, to which it is very liable; and that a slight tinge of yellow and even a few bubbles were not very injurious. I have made many experiments to obtain a crystal glass free from veins, but have met with great difficulties. The veins are undulated, like those which appear when two liquors of different densities, as water and spirit of wine, are added together, and before they are well mixed. This appearance shews, that something similar happens in the making of glass. I endeavored to correct this fault by a very careful mixture, and by a complete fusion. But I found, that although I have exposed these glasses to very violent and long continued fires, and have several times pulverised and ground them, and repeated the fusion, I have not been able to procure any perfectly free from veins. I have been prevented by other necessary occupations from continuing my experiments on this subject. But although those which I have made sufficiently shew the difficulty of making glass of the required density, and which shall be perfectly free from veins, this difficulty nevertheless does not appear unmountable; and I do not doubt but that by patiently prosecuting this inquiry, we may arrive at the desired success.

We shall observe, in concluding this article, that several causes lessen or entirely prevent the transparency of glass, which is one of its most necessary qualities. As we cannot melt vitrifiable earth into transparent masses but by means of fluxes, and a sufficiently strong and long-continued heat, therefore when the vitreous mixture contains too little flux, or is exposed to too little heat, some parts of the vitrifiable earth cannot be entirely fused, and therefore defect in it or less, according to their quantity, the transparency of the glass. The same fault may be perceived in glass, when it contains some earthy matter not susceptible of the action of fluxes, as vitrifiable earth is; such as, for instance, metallic earths that are too much dephlogistigated, particularly the earth of iron. Accordingly, these earths are employed to make opaque or semi-transparent glasses, as enamels, artificial opals, and other such stones. Another remark may be made concerning the transparency of some kinds of glass, that it is destructible by a too long exposure to violent heat. As all fluxes, phlogiston, or saline, are much less fixed than vitrifiable earth; and as some fluxes are less fixed than others, or less capable of becoming fixed by being mixed with vitrifiable earth; the cause therefore of the loss of transparency which some glasses suffer by a too violent fire, is, that a part of their flux is dissipated, so that the glasses are decomposed, and that they contain so much earth that the flux is incapable of keeping them completely fused. I have observed that glasses formed by a mixture of argillaceous, and gypseous or calcareous earths are more liable than any others to this loss of transparency. See ALKALI, EARTH, FURNACE, and several other articles relating to vitrification.

**VITRIOL.** *VITRIOLE.* This name is particularly applied to three mineral vitriolic salts with metallic bases. These salts are, 1. The combination of vitriolic acid with iron, called *martial vitriol*, *English vitriol*, *green vitriol*, or *green copperas*. 2. The salt resulting from the union of the same acid with copper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, or *blue copperas*. 3. The

3. The salt composed of vitriolic acid with zinc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *Gesslar vitriol*.

We have observed under the articles *vitriolic acid* and *salts*, that the name *vitriol* ought to be applied to all vitriolic salts with metallic basis. Thus, for instance, the salt composed of vitriolic acid and gold may be called *vitriol of gold*; and the salt formed by the union of this acid with silver may be called *vitriol of silver*, or *lunar vitriol*. Perhaps all vitriolic salts might be conveniently comprehended under the general name *vitriol*. The properties of vitriolic salts are mentioned at the articles, ACID (VITRIOLIC), ALKALIS, EARTH (CALCAREOUS), SALTS, SELENITES, GYPSUM, ALABASTER, SPAR, SMELTING OF ORES, and of the several metallic substances.

DCCXX. UMBER. (1)

DCCXXI. VOLATILITY. Volatility is a property that many bodies have of being reduced into light vapors, which exhale when they are exposed to the action of fire. This quality is opposed to *fixity*. The cause of it is the greater or less *dilatability* which bodies have when exposed to fire. Perhaps every body is, rigorously speaking, volatile: but as there are some the volatility of which can be only rendered sensible by the action of a fire much more violent than any which we can produce, we consider these bodies as being fixed, or not volatile. See FIRE and FIXITY.

DCCXXII. URINE. As urine is an excrementitious animal liquor, it contains only such principles as are useless or hurtful to the animal economy; and is accordingly found to be nothing but a lixivium of different saline substances, which cannot enter into the composition of an animal body, together with a quantity, not very considerable, of a saponaceous, extractive, and very putrescent matter. In urine we find none of the gelatinous substance that is contained so copiously in other animal liquors that are not excrementitious; for this gelatinous substance, as we have said under the article JELLY, is the principal constituent, nutritive, and reparative part of animal bodies, and could not therefore without some considerable fault or disorder in the animal economy be rejected with any excrementitious matter. The urine of healthy animals is therefore nothing but a serous saline liquor, that may be entirely evaporated, without shewing any gelatinous matter.

The fresh urine of healthy animals is transparent, and something yellowish or citron-colored, has a slight smell, a saline nauseous taste, and does not change the color of syrup of violets to a red or to a green: but this liquor varies considerably when the animal economy, and especially the digestive organs are disturbed. Accordingly, physicians carefully observe the urine of their patients; but although they often receive much assistance from such observation, it is a dangerous error that quacks lead many ignorant persons into, to believe, that by the mere inspection of urine all diseases may be discovered.

(1) UMBER. Umber is a very light, dusky-colored earth, which is somewhat inflammable, and emits a strong smell when it is burnt. By calcination it is changed, according to Wallerius, to a white earth, and, according to Linnæus, to a red earth; whence the latter author conjectures that it contains some iron. It seems not to have been much examined.

Physicians, who have passed their lives in an attentive observation of the signs of diseases, are too sensible of the insufficiency of every aid to decide certainly concerning the nature of many diseases. But this reflection ought to be a motive to inquire into the various changes that urine undergoes in different states of the body, more accurately than has been hitherto done, especially as the improvements daily made in chemistry may give us hopes of throwing more and more light upon this and other interesting subjects.

The qualities of urine are very apt to vary considerably, even without any very perceptible derangement of the animal economy. For instance, it is sometimes much more copious than at other times. This difference of the quantity of urine has been observed to depend much on the quantity of perspiration and of sweat that have been exuded at the same time; for the nature of these fluids is very similar to that of urine. Generally, when the urine is in small quantity, it is deeper colored; and reciprocally.

The urine of persons afflicted with hysterical and melancholical spasms is frequently copious, limpid, and purely watery or serous, without color or smell. This urine is called *crude urine*. These same persons do also frequently discharge urine in small quantity, that is high-colored, that has a strong smell, and that quickly becomes turbid when exposed to cold. We may observe, that the sediment which renders this urine turbid may be again redissolved by more fresh and warm urine, and is therefore of a saline nature.

Certain odoriferous substances, taken internally, as turpentine, asparagus, and others, are well known to communicate quickly their smell to urine, even in perfect health: but I have also seen persons subject to pains of the head and to bad digestion, proceeding from a melancholic or hysterical temperament, who discharged urine, in which I could evidently perceive the smell of coffee, spices, onions, fruits, roots, and even of broth, and other aliments. The urine of these persons was habitually acid, reddened syrup of violets and blue paper, when it was recent, and especially after eating fruits and roots, or drinking even a very small quantity of wine.

From these two latter observations we may perceive, that urine depends much on the state of digestion, the faults of which may therefore be discovered by examining that liquor.

Urine is strongly disposed to putrefaction. In ten or twelve hours, when the weather is warm, it acquires a strong smell; and in great heats, this smell may be perceived in five or six hours. The beginning of the putrefaction of this liquor may be perceived by a putrid, disagreeable, but not pungent smell. The smell afterwards becomes pungent, and discovers a volatile alkali, which is very copiously disengaged in the putrefaction of this liquor. Although the disagreeable smell that is perceived at first in urine beginning to putrefy has not the pungency of volatile alkali, it nevertheless seems to be produced by this salt; for by mixing any acid with urine in this state, its fetid smell is immediately destroyed. By the same means also the smell of vessels in which urine has been contained may be destroyed. On the contrary, by mixing some fixed alkali or quicklime with fresh urine, a pungent smell of volatile alkali and of putrid urine is instantly produced. As in so short a time no real putrefaction can happen, we must attribute the discharge of volatile alkali in this experiment to a decom-



a decomposition of a fal ammoniac, which is contained in the freshest urine, as we shall soon shew.

If the fresh urine of a healthy person be distilled in close vessels, nothing is obtained from it with the heat of boiling water, but a pure phlegm with a slightly nauseous smell. This phlegm is generally  $\frac{2}{3}$  parts or more of the whole urine; but the quantity of this and of the other principles of urine are very various.

As nothing but phlegm is separated at first in this distillation, when therefore urine is to be analysed, the operation may be accelerated and simplified by evaporating it over the fire in an open vessel. We may then observe, that while the phlegm of the urine is evaporated, the remaining liquor becomes turbid, and deposits a certain quantity of matter which is almost entirely earthy. The quantity of this earth varies also according to the nature of the urine. It deserves a particular examination. The observations of Mr. Herissant, Physician of the Faculty of Paris, and Member of the Academy of Sciences, concerning the urine of several persons afflicted with diseases in which the bones were affected and wasted (*See Memoirs of the Academy for the year 1758*); and those also of Mr. Morand, of the same Faculty, and Member of the same Academy, concerning the urine of a woman whose bones were entirely softened by the loss of their earthy matter, which was found to contain a considerable quantity of earthy sediment; shew, that the earthy sediment of urine, which is first deposited by evaporation, is partly at least of the same kind as the earth of bones; and that in a healthy state, nature throws off by the urinary passages all the earthy matter that is not required for the encrease or reparation of the bones. This earthy sediment appears also in putrid urine.

While the urine evaporates, the remaining part of it acquires a more and more deep brown color, by the approximation of the saponaceous extractive parts which it contains. When, by evaporation, it has acquired the consistence of a clear syrup, or of fresh cream of milk, it ought to be put in a cool place, that the several neutral salts which it contains may be crystallized. The first crystals that are obtained are a particular kind of salt known to chemists by the names, *native or essential salt of urine, fusible salt of urine, phosphoric salt, and microcosmic salt*. This salt contains the acid proper for making phosphorus. Some part of this salt has a basis of volatile alkali, and is therefore a kind of ammoniacal salt; and the rest has a basis of fixed alkali. *See SALT (FUSIBLE) of URINE, and PHOSPHORUS of KUNCKEL*. When the urine contains any salts that are more crystallizable or less soluble than the fusible salt, as it frequently does, such as selenites, vitriolated tartar, and others, these are first crystallized, especially if they be in considerable quantity. *See CRYSTALLIZATION*.

By alternately evaporating and cooling the liquor, the other less crystallizable salts, such as common salt, a great quantity of which urine generally contains, may be separated. In the urine of different animals all the neutral salts are generally found which they have taken, either along with their aliments or otherwise; because these salts, not being useful in the composition of animal matters, after having circulated some time in the blood-vessels, are carried off, unchanged, along with the urine.

After all the neutral salts have been obtained from urine, nothing remains but a brown, saponaceous, extractive matter, which forms a kind of mother-

water. This matter yields, with a naked and graduated fire, a considerable quantity of volatile alkali, both fluid and concrete, together with some fetid animal oil. With the utmost violence of fire, a small quantity of phosphorus may also be obtained; and a little common salt may be separated from the residuous coal. This phosphorus is produced by a little fusible salt which was not separated by crystallization, but remained, together with the above-mentioned small quantity of common salt, dissolved in the liquor.

From this analysis of urine we may perceive, that it is composed of a large portion of pure water, in which is dissolved a considerable quantity of earthy matter, that forms the sediment of urine; of two phosphoric salts, one of which is ammoniacal, and the other has a basis of fixed alkali; of common salt; and, lastly, of a saline, saponaceous matter, which contains a combined oil. In urine no gelatinous matter nor uncombined oil are found.

Such is the state of our present knowledge concerning the nature and principles of urine. It certainly is capable of receiving much addition from future inquiries, by which medicine might be much improved; but we must, at the same time, confess, that we cannot receive all the knowledge we wish upon this subject without very long and laborious operations. The most important point to be known is the composition and proportions of the several constituent parts of urine: but, as we have already remarked, these are very variable, according to the state of health or of sickness, to the differences of constitutions, aliments, exercises, diseases, medicines, and perhaps even to the variations of the atmosphere. A knowledge of the differences of the urine in all these several circumstances is very important, but can only be acquired by a long and zealous observation of those physicians who are instructed in the several sciences relative to their profession.

## W.

DCCXXIII. **W** A N D (D I V I N I N G). The divining wand is an instrument, by means of which many persons have formerly pretended, and some do now pretend, to discover under what parts of the earth metals, treasures, ores, water, salt, &c. lie hid, without digging the ground. They say, this discovery may be made by a person holding the wand horizontally, and by walking along in places where these matters are expected; and that when he arrives at a place under which any of the above-mentioned matters lie, the wand will be forcibly inclined towards that place: but that this experiment should succeed, much faith seems to be required in the person who holds the wand, or rather in the spectators. We may easily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many interesting particulars are found concerning mines, justly derides these superstitious practices, and denies, from his own experience, the truth of the assertions concerning them. He seems, however, to have some faith in sympathies, and proposes even new divining wands of his own invention; the effects of which, though more dependant on physical causes, are not however more certain. He believes, for instance, that a wand, one end of which should be made of sal gem, and the other of wood, being suspended and balanced above a mine of salt, would be inclined towards the ground; and he supports his opinion by an experiment. This experiment consists in evaporating over the fire a solution of sal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemistry to discover, that the wand would have inclined in the same manner if Father Kircher had evaporated pure water instead of a solution of sal gem; because the water would have equally well attached itself to the saline end of the wand; consequently this experiment proves nothing.

The same author proposes also to discover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes  
that

that the emanations of the mercury would attach themselves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unless the mercury was evaporating; for which purpose two conditions are necessary: 1. The mercury must be in a native metallic state, and not mineralised, as it is in cinnabar; and, 2. It must also be exposed to the heat of some subterranean fire, by which it is volatilised and sublimed, the ordinary heat of the earth being far too little for this purpose. This second physical or chemical divining wand proposed by Father Kircher is therefore no better than the former; and probably the same judgment may be past upon all other wands made upon the same principles, and in imitation of these. Lastly, the same author positively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of some wood that has no sympathy with water, over a subterranean water, and that he observed the end of the wand incline towards the earth.

DCCXXIV. W A T E R. Water, perfectly pure, (for of such only we treat in this article) is a transparent body, without color, without smell, and without taste.

Water is very volatile, and so very fusible, that it is constantly liquid with a less degree of heat than is requisite for vegetation: hence it is generally considered as a liquid. But when it is exposed to a less degree of heat, it becomes solid, like all other bodies naturally solid, which resume their solidity when they are no longer exposed to a heat sufficient to keep them in fusion.

When water, that is exposed to a degree of cold sufficient to render it solid, passes from a fluid to a solid state, this change is called the *congelation* or *freezing of water*; and the water thus rendered solid is called *ice*.

When water is frozen with all the circumstances necessary for the free arrangement of the integrant particles of bodies (which circumstances are explained under the article CRYSTALLIZATION), it assumes determinate and regular forms. M. de Mairan, in his excellent Treatise on Ice, has determined, that these regularly formed masses of frozen water are like needles crossing each other, or rather infixed into each other, so as always to form two angles, one of which is equal to sixty degrees, and the other equal to a hundred and twenty degrees.

This regularity in the congelation or crystallization of water shews, that it is a body not much compounded. We shall soon see that it is one of the simplest of all known bodies.

Water is not compressible. This truth is ascertained by a famous experiment, which consists in including water in a hollow sphere of metal hermetically closed, and in exposing this sphere to a very strong compression, by which means the water is forced through the pores of this metallic sphere rather than suffer any compression. (r)

(r) The validity of the inferences drawn from this experiment, called the *Florentine experiment*, has been justly questioned. An ingenious philosopher, Mr. Canton, has proved, by experiments shewn to the Royal Society, that water is actually compressed by the weight of the atmosphere. The diminu-

tion of size that water suffers when it passes from a greater to a less degree of heat, till it begins to freeze, sufficiently shews, that the integrant parts of this fluid are, like those of all other known substances, capable of approximation.

The specific gravity of water, compared with that of air in a temperature intermediate betwixt the greatest summer heats and the greatest cold of winter, has been determined by the best experimental philosophers to be nearly as 850 to 1; that is to say, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have said above, that water is a very volatile body. It is entirely reduced into vapors and dissipated, when it is exposed to the fire, and is not confined.

When water is heated in an open vessel, and is unconfined, it has been observed to acquire no more than a certain determinate degree of heat, whatever be the intensity of the fire to which it is exposed; which greatest degree of heat is that which it has when it boils quickly. This degree of heat, and also that degree at which water begins to freeze, are fixed and determinate, and are therefore very useful in many chemical and physical experiments. By means of these fixed points of heat, we have been enabled to construct thermometers, which may always be compared one with another; and we have also been enabled to apply precise and determinate degrees of heat, which are necessary in many chemical operations. See BATH (WATER).

Some philosophers have said, that the property which water and some other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction caused by this degree of heat, by which means the fire penetrates them freely and without any resistance. See FIRE. But this opinion is erroneous. The cause of this phenomenon evidently is, that water being volatile, is reduced into vapors which are constantly exhaled and removed from the fire, the action of which they elude as soon as they suffer a certain degree of heat, as may be proved by the following considerations.

First, none but volatile bodies have this property; bodies absolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the less heat it can acquire, and reciprocally; or, to speak geometrically, the degrees of heat which bodies exposed to the action of fire, and unconfined, can acquire, are inversely as their volatility, and consequently directly as their fixity.

Secondly, when water and all volatile bodies are exposed to the action of fire, and so confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more considerable, is indeterminate, or rather proportionable to the force with which they are confined, and prevented from evaporating.

We have an obvious example of this in the effects of *Papin's Digester*. Water being confined in this vessel so that it cannot evaporate, is capable of acquiring a degree of heat much greater than that with which it boils in open air, and even sufficient to make it red hot.

Upon this subject we must observe, that when water, or other volatile bodies, are thus exposed to a greater degree of heat than is suited to their volatility, they are in a violent state; and are therefore apt to break any vessels that confine them, with an explosion so much more violent, as they are more strongly compressed, and are exposed to a more violent and more suddenly applied heat.

Hence we may conceive why water exposed to heat too suddenly to allow it to evaporate gradually occasions terrible explosions; as, for instance, when water

water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moist vessel.

We ought to observe upon the subject of these explosions, that they only happen when the volatile bodies are in an aggregate state, or are combined with other volatile bodies; for the most volatile substances, when combined with fixed bodies, may be exposed to the most violent heat without producing these effects. Thus water, when combined with quicklime, with fixed alkali, and other salts, may be suddenly exposed to a red-heat without danger of explosion.

Water seems to be unalterable and indestructible: at least, no experiment is hitherto known from which we may infer that water may be decomposed. With whatever substances it may be combined, when separated from these and sufficiently purified, it is always found to be the same as before. When it is distilled singly, or mixed with some other substance, its nature and essential properties still remain unchanged.

Some philosophers, as Boyle, and especially Mr. Margraaf, having very frequently distilled the same water, obtained at each operation a small portion of earth; but the water which was distilled remained always essentially the same. The small quantity of earth separated from the water ought to be considered as extraneous to it.

The famous experiment of Van Helmont, which has since his time been more carefully repeated by others, and which consists in making trees and plants grow merely by means of water, does not prove, as some have supposed, that pure water is convertible into earth, salts, oil, and the other principles of vegetables; because water not only contains a small quantity of earth mixed with it, but also the air alone is the vehicle of a considerable quantity of these principles, or of such as are capable of producing them.

Water therefore appears to be a body simple and unalterable: at least, chemists, not having any means of decomposing it, may consider it as such. They have accordingly classed it amongst the *elements* or primary principles. See *ELEMENTS and PRINCIPLE*.

Many experiments and chemical analyses shew, that water enters as a principle in the combination of many compound bodies, such as all saline and oily substances (See *SALT and OIL*); and consequently that it is a part of all vegetable and animal matters, and of all the saline parts of minerals. Several stones even, in which no saline matter appears, as calcareous stones, contain a certain quantity of water, which seems to be in a state of combination. See *EARTH (CALCAREOUS) and QUICKLIME*. But hitherto no experiment shews, that water enters as a principle into the combination of *metallic matters*, or even into that of *vitreous stones*. See *these words*.

Water dissolves many bodies. It seems to be capable of dissolving a certain quantity of air; for all natural water being placed under an exhausted receiver emits many air-bubbles; and, according to Mr. Musschenbroek, the water from which air has been thus separated, is capable of resuming the same quantity of air; that is to say, if a small quantity of air be introduced into this water, it will not form a bubble, as it would with water already saturated with air, but incorporates with the water, and entirely disappears.

Water seems also capable of dissolving a small quantity of calcareous earth; for the most limpid, clear water being distilled, always deposits some part of this

this earth. Some very limpid spring waters contain so much calcareous earth, that they deposite a sediment which encrusts any bodies that happen to be immersed in them. These waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all those which form incrustations, petrefactions, and stalactites. This earth does not seem to adhere very strongly to the parts of water, especially when it is in considerable quantity. It seems to be in an intermediate state betwixt that of simple mixture and of perfect combination with the water.

Metallic matters, excepting the perfect metals, are acted upon by water, but especially by the vapor of water, together with the concurrence of air. It converts their surfaces into rust, and deprives them of part of their inflammable principle. It does not appear to be disposed to unite with the principle of inflammability; for all the bodies that are abundantly furnished with this principle resist the action of water, unless they have also some other principle that may serve as an intermediate substance for this union.

But, of all known bodies, saline substances are most easily and copiously soluble in water. A strong affinity is observable between this element and all saline substances; so that we may say in general, that all salts are soluble in water; that every body truly soluble in water is of a saline nature; and that no other body can be dissolved in water but by means of a saline substance. *See SALTS.*

Spirit of wine, and all ardent spirits of the same kind, may be dissolved in water in all proportions. *See SPIRIT (ARDENT).*

The spiritus rector of vegetable and animal substances, and most of the very thin and very volatile fluids, called *gas*, are soluble in water. *See these words.*

Ethereal liquors, as vitriolic, nitrous, marine, and acetous ethers, are soluble in water, but only in certain proportions. *See ETHER.*

Water dissolves the most subtle and volatile part of any oils, as Mr. Beaumê has observed. *See OILS.*

Compounds, formed of any oily matters united with saline matters, (to which compounds we ought to give the general name of *soap*, or *saponaceous substance*) are soluble in water, so much more easily and copiously as their saline principle is in greater quantity, and more disengaged or unfolded. *See SOAP.*

Lastly, water is the proper solvent of all mucilaginous, gummy, and gelatinous matters; which matters are composed of saline, oily, and earthy principles. *See GUM.*

We may easily perceive from what has been said concerning the properties of water, that it must be very useful in many chemical operations: but as it dissolves so many bodies, it can seldom be found naturally free from heterogeneous matter, or perfectly pure. The waters of rivers and of springs, however limpid they may be, always contain a certain quantity of earth, which is in the intermediate state above-mentioned, between a simple interposition of parts, and a true solution. The best waters of this kind are those which flow through sands, grit-stone, and other vitrifiable matters; because vitrifiable earth is least capable of being attacked by water.

The waters of many springs and rivers contain more or less of a gypseous or selenitic substance really dissolved; for as water is capable of dissolving these matters, and often flows through grounds containing them, it must dissolve a certain quantity of them, and even as much as saturates it. Waters impregnated with selenites are unfit for chemical operations, for being drank, for dissolving soap, or for boiling leguminous vegetables. They are a kind of *mineral waters*, and are called *crude* or *hard waters*. See these words.

Rain or snow-waters, properly collected, that is, not in stormy weather, after it has already rained or snowed some time, in open air, and far from the habitations of men, and received in earthen-ware vessels, are the best and the purest of all native waters. They are sufficiently pure for most chemical operations, because they have been purified by a kind of natural distillation: but for greater exactness, and because these waters are not always procurable, distilled water is generally employed in chemical operations. See WATER (DISTILLED).

(s) Native water is seldom, if ever, found perfectly pure. The waters that flow within, or upon the surface of, the earth contain various earthy, saline, metallic, vegetable or animal particles, according to the substances over or through which they pass. Rain and snow-waters are much purer than those, although they also contain whatever floats in the air, or has been exhaled along with the watery vapors. Mr. Margraaf has very accurately analysed some rain and snow-waters, and found that they contained a calcareous earth united with nitrous and marine acids, the rain possessing more of the former, and the snow more of the latter acid, together with some mucilaginous, oily, and ferruginous particles. The quantity of calcareous earth separated, by adding a fixed alkali, from a hundred measures of water, each of which contained 36 ounces, was 132 grains; and the quantity separated by the same means from an equal quantity of snow-water was 72 grains.

The purity of water may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the substances usually dissolved in water, fixable and atmospheric air excepted, are heavier than water, but also the specific gravity of a solution of any of these substances in water is greater than the intermediate specific gravity of the water and of that substance. We must nevertheless observe, that as fixable and atmospheric airs are frequently contained in water, they render it less heavy than it would otherwise be. Hence Bath, and other waters containing much fixable air, are lighter than

distilled water, although the former contain saline, metallic, and earthy substances.

2. Pure water is more fluid than water that is not pure: hence it is said to occasion a louder sound when poured from one vessel into another.

3. It has no color, smell, or taste.

4. It wets more easily than the waters containing metallic and earthy salts, called *hard waters*, and feels softer when touched.

5. Soap, or a solution of soap in spirit of wine, mixes easily and perfectly with it.

6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury in nitrous acid, or a solution of sugar of lead in water.

Boerhaave, the author of this Dictionary, and other chemists, maintain, that pure water is unalterable; and others, as Borchius, Boyle, Wallerius, that it may be decomposed or resolved into other principles, especially into earth.

Boyle relates, that one ounce of water, distilled carefully in glass-vessels two hundred times, yielded six drams of a white, light, insipid earth, fixed in the fire, and indissoluble in water. Boerhaave attributed the earth obtained by distillation of water to dust floating in laboratories. Other chemists have made experiments to ascertain the truth of that of Mr. Boyle. Liedenfrost found, that when pure distilled water is dissipated or evaporated by throwing it into a red-hot iron spoon, he always obtained a quantity of earth. Wallerius obtained a scruple and a half of fine white earth by triturating during two hours a dram of distilled water.

This



DCCXXV. W A T E R S (A R O M A T I C). These are called aromatic waters that are impregnated by distillation with the spiritus rector, or odoriferous principle of aromatic matters. See WATERS (DISTILLED).

This earth, he says, is soluble in acids, is convertible into a hard mass by a red-heat, which mass is insoluble by acids, and is vitrifiable into a white transparent glass by a more violent heat. He found also, that a large quantity of earth is deposited from boiling water with a strong, then with a gentle fire. See the *Swedish Memoirs for the year 1760*. Mr. Margraaf has made experiments with his accustomed accuracy, from which it appears, that, by distillation, and also by evaporation with the heat of the sun, of rain water, the purity of which had been previously ascertained by thirteen distillations, he obtained a white, light, shining earth. This earth could not be vitrified with the heat requisite for the fusion of ordinary glass; but by a more violent and longer continued fire it was melted into a yellow-greyish mass. He found, that about half of this earth was soluble in nitrous acid, and that the other half was not fusible by fire; but that, by addition of half its quantity of salt of tartar, it was convertible into a transparent glass. The part of the earth that was dissolved in nitrous acid was afterwards precipitated from that acid by vitriolic acid, with which it formed a selenites; and hence Mr. Margraaf infers, that it is a true calcareous earth. He does not determine the class of earths to which the insoluble part of the earth thus obtained by distilling water ought to be referred. Mr. Margraaf observes, that earth is more copiously deposited from water boiling with a strong than with a gentle heat. The quantity of earth that he obtained, in one experiment, from 72 ounces of distilled water, by twelve distillations, was nine or ten grains.

Mr. Eller relates an account of a more extraordinary alteration produced upon water, by which other principles were formed. He enclosed some distilled water in a glass phial, which he then hermetically sealed, and exposed during some weeks in summer to the rays of the sun. At the end of this time he perceived that it was become turbid, and covered with a scum or pellicle. By distil-

lation he obtained from this water a reddish oil, and some acid fumes. That so extraordinary an alteration can be produced upon pure water by the rays of the sun, cannot be admitted till the experiment has been carefully repeated with the same success.

To this article we shall subjoin three tables of different authors, shewing what quantity of each salt is soluble in a given quantity of water; and also an account of some experiments made by Mr. Eller, to shew how much of certain salts may be dissolved in given quantities of water saturated previously with other salts.

The following table shews the quantities of the saline substances that could be dissolved in an ounce of water, with the heat of 50° of Fahrenheit's scale, according to experiments made by Mr. Spielman. *Instit. Chæmiæ*, p. 48.

	Grains
Terra foliata tartari	470
Salt of Sedlitz	384
Epsom salt	324
Salt of tartar	240
Vegetable salt	212
White vitriol	210
Sal gem	200
Salt of soda	200
Sal ammoniac	176
Common salt	170
Salt of Glauber	168
Salt of Lorraine	168
Salt of Sylvius	160
Salt of Seignette	137
Blue vitriol	124
Green vitriol	80
Purified nitre	60
Salt polychrest of Glauber	40
Vitriolated tartar	30
Sublimate mercury	30
Borax	20
Alum	14
Volatile salt of amber	5
Arsenic	5
Crude tartar	4
Cream of tartar	3

DCCXXVI. WATER (DISTILLED). Most natural waters contain some heterogeneous substances that render them impure; and as water exceedingly pure is required for many chemical operations, it must be therefore purified for these purposes by distillation. Water may be distilled in the following manner:

The following table is copied from Mr. Muschenbroek. The eight first experiments were made by Boerhaave, and the rest by Muschenbroek, with a heat of  $38^{\circ}$ .

Sea-salt,	oz. 2.	were dissolved in	oz. 6. and dr. 3. of pure water.
Sal gem,	oz. 1.	_____	oz. 3. and dr. 2. _____
Sal ammoniac,	oz. 1.	_____	oz. 3. and dr. 2. _____
Nitre,	dr. 9.	_____	oz. 6. _____
Borax,	dr. 4.	_____	oz. 10. _____
Alum,	oz. 1.	_____	oz. 14. _____
Epsom salt,	oz. 1.	_____	oz. 1. and dr. 2. _____
Green vitriol,	dr. 1½	_____	oz. 3. _____
Arsenic,	oz. 1.	_____	oz. 30. _____
Blue vitriol,	gr. 50.	_____	gr. 850. _____
Salt of hartshorn,	gr. 50.	_____	gr. 765. _____
Sugar of lead,	gr. 50.	_____	gr. 595. _____
Salt of tartar,	gr. 50.	_____	gr. 85. _____
Glass-gall,	gr. 50.	_____	oz. 7½. _____
Cream of tartar,	gr. 50.	_____	gr. 1000. _____ of boiling water.

[Fifty grains of cream of tartar may be dissolved in 100 grains of lime-water, *Hist. de l'Acad. Royale. 1732.*]

Sugar of milk, dr. 7. were dissolved in lb. 1. of water heated to the  $167^{\circ}$ .

According to Neuman's experiments, the quantity of salt soluble in an ounce of water are expressed in the following table. He does not mention the heat employed.

White powdered sugar,	oz. 2.
Brown powdered sugar, —	oz. 2.
White or brown sugar candy,	dr. 9.
Sal diureticus — —	oz. 1.
Epsom salt, — — —	oz. 1.
Sedlitz salt, — — —	dr. 6.
Pure fixed alkali, — — —	dr. 6.
White vitriol, — — —	oz. ½.
Martial vitriol, — — —	oz. ¼.
Sal gem, — — —	dr. 3. scr. 1.
Sea-salt, — — —	dr. 3.
Salt of Glauber, — — —	dr. 2.
Sal ammoniac, — — —	dr. 2.
Vol. sal ammoniac, — —	dr. 2.
Potash, — — —	dr. 2.
Blue vitriol, — — —	dr. 2.
Pure nitre, — — —	dr. 1. gr. 10.
Sal prunell, — — —	dr. 1.
Soluble tartar, — — —	dr. 1.
Alum, — — —	scr. 2½.
Sal polychrest, — — —	scr. 2.

Arcanum duplicatum, —	dr. ½.
Vitriolated tartar, — —	dr. ½.
Sugar of milk, — — —	scr. 1.
Sugar of lead — — —	scr. 1.
Emetic tartar, — — —	scr. 1.
Borax, — — —	gr. 15.
Salt of sorrel — — —	gr. 10.
White tartar, — — —	gr. 5.
Crystals of tartar, — — —	gr. 5.

Water, when saturated with one salt, is capable of dissolving a considerable portion of another salt; and when saturated with this also, it may still dissolve a third, a fourth, or more salts. Thus, according to Neuman, four ounces of water that have been saturated with a dram and a few grains of alum, will still dissolve five drams of nitre, then half an ounce of green vitriol, six drams of common salt, three drams of soluble tartar, and five drams of sugar. In the same manner also, four ounces of water saturated with half an ounce of nitre, will dissolve half an ounce of white vitriol, six drams of common salt, six drams of sal ammoniac, half an ounce of soluble tartar, and

The purest natural water that can be procured, as the water of rain or of snow, or of springs and rivers that flow over sands, and are very limpid, is to be put into a well-tinned copper alembic, which must be very clean, or which is only employed for this purpose, and the distillation is to be promoted with a gentle fire.

The first portion of water that passes into the receiver ought to be thrown away, because it washes the alembic and receiver, and because if the water contained accidentally any volatile heterogeneous matters, these will rise with the first portion of distilled water.

The distillation is to be discontinued, when two-thirds of water have nearly passed, because what remains in the alembic, is loaded with a larger proportion of heterogeneous substances, some of which the water might raise along with it in distillation. See DISTILLATION.

Distilled water ought to be put into very clean bottles, and stopped with glass stopples.

Water is known to have been sufficiently purified by distillation, when it does not change the color of the tinctures of violets, or of turnsol, and when its limpidity is not hurt by adding to it solutions of mercury or of silver in nitrous acid.

**DCCXXVII. W A T E R S (D I S T I L L E D).** The *distilled waters of plants*, or of other matters, are prepared by distilling water from these substances, and are thus impregnated with such principles as may be raised by distillation, with the heat of boiling water.

If the plants thus exposed to distillation with water, manifestly contain volatile principles, as all those do which have a distinguishing smell, we cannot doubt

and after all these, an entire ounce of sugar.

Mr. Eller has published an account of the following experiments concerning the solution of different salts in the same water. See *Mém. of the Acad. of Berlin for the year 1750.*

In each experiment he employed eight ounces of distilled water. He found that this quantity of water, when saturated

*With four ounces of nitre*, dissolved one ounce, five drams of fixed alkali, and half an ounce of common salt:

*With three ounces, one dram, and one scruple of common salt*, dissolved three drams of nitre, and five drams of fixed alkali:

*With three ounces and a half of fossil salt*, dissolved half an ounce of nitre:

*With half an ounce of cream of tartar*, dissolved half an ounce of Sedlitz salt, and half an ounce of fixed alkali:

*With an ounce and a half of diacidulated tartar*, dissolved half an ounce of fixed alkali:

*With three ounces and a half of Glauber's salt*, dissolved two drams of nitre, and as much sugar.

*With four ounces of soluble tartar*, dissolved half an ounce of pure nitre.

*With four ounces of Epsom salt*, dissolved half an ounce of fine sugar.

*With two ounces and a half of sul ammoniac*, dissolved five drams of fossil salt.

*With an ounce and a half of volatile salt of hartshorn*, dissolved an ounce of nitre and half an ounce of sugar.

*With four drams and two scruples of borax*, dissolved half an ounce of fixed alkali.

*With two ounces and a half of alum*, dissolved six drams of common salt, and one dram of Epsom salt:

*With nine ounces and a half of green vitriol*, dissolved an ounce and a half of Sedlitz salt, two drams of nitre, and three ounces of refined sugar:

*With nine ounces of blue vitriol*, dissolved an ounce of nitre, three drams of common salt, and an ounce of sugar:

*With four ounces and a half of white vitriol*, dissolved one ounce of refined sugar.

that their distilled water must be impregnated with their odoriferous principle, or spiritus rector. These waters are called *aromatic waters*. See SPIRITUS RECTOR.

The water that is used in the distillation of all essential oils is found much impregnated with the odoriferous principle of the aromatic plants employed; and consequently it is a good distilled water of these plants.

An opinion seems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with some of their principles by distillation; for such distilled waters are prescribed in many dispensatories. But lately, these distilled waters have been neglected, and are even considered only as common water. This latter kind of distilled waters is sensibly less impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are those plants whose smell is not very perceptible, entirely destitute of all odoriferous principle? Could not a person whose sense of smell was very acute and much exercised, distinguish plantain and other herbs commonly called inodorous from each other by smell, especially if they were previously cut and bruised?

We may also observe, that the manner commonly employed for distilling such waters is not well adapted to procure all the peculiar smell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The distillation is then promoted; the water is made to boil quickly; and the vessels are seldom even luted. What can be expected from this bad management, but that the spiritus rector of these plants that is in very small quantity, and perhaps exceedingly volatile and fugacious, should be entirely dissipated; or if any of it remains in the water, that it should be disguised and covered by the empyreumatic smell that all these waters have when newly distilled, or by the smell which they acquire by time, so that they cannot be distinguished from each other?

But if we follow exactly the excellent method directed in the Paris Dispensatory; or if we improve upon this by putting the herbs recent, cut, and bruised, into an alembic placed in a water-bath, without adding water to them, and by distilling to dryness, with a very gentle heat and well luted vessels; and if we then find that the small quantity of water thus distilled from plants called inodorous has no smell nor taste, and gives all the chemical proofs of pure water, we may then justly consider these waters as destitute of any of the principles and virtues of the plants employed.

Waters called simply *distilled waters*, are understood to be those that are prepared with common water. But as spirit of wine is also frequently impregnated with the odoriferous principle of plants and other substances by distillation, and as these also have been called *waters*, they ought to be distinguished by the name, *aromatic spirituous waters*. Such are the *spirituous water of Lavender*, the *spirituous water of thyme*, &c. These spirituous waters are also sometimes called *spirits*, as *spirit of thyme*, *spirit of citrons*, &c.

Aromatic spirituous waters are impregnated with the smell of one substance only, or of several substances. The former are called *simple*, and the latter, *compound*.

Many of these waters are prepared for the uses of medicine, of the toilette, and of the table. The preparation of these waters requires only the usual attentions to be given to all distillations. Whatever relates to this subject may be found in *Mr. Beaumé's Elements of Pharmacy*. We shall there see that the strength

strength and agreeable flavor of these waters chiefly depend on the strength of the spirit of wine employed, and especially on its purity from any oil of wine, which gives the disagreeable smell and taste of common aqua vitæ. See SPIRIT (ARDENT).

DCCXXVIII. W A T E R S (H A R D or C R U D E). These names are applied to all waters that contain any sensible quantity of earth or selenites. See WATERS (MINERAL). (t)

DCCXXIX. W A T E R (L I M E). Lime-water is ordinary water in which quicklime has been slaked.

Water in which quicklime has been slaked, or with which slaked quicklime is washed, dissolves the part of the quicklime that is most attenuated, and nearest to a saline state: this substance, which may be considered as saline and earthy, communicates to water an alkaline, and somewhat acrid taste. The effects of lime-water in chemical mixtures are similar to those produced by quicklime. See QUICK-LIME.

Although lime-water contains no volatile principle, it ought nevertheless to be preserved in full and well closed bottles: otherwise the saline earthy matter dissolved in it, to which it owes all its peculiar properties, would be separated from it, in proportion as the water should be evaporated, and would appear on the surface in form of a crust, called *cream of lime*. The quantity of calcareous matter that is thus separated from lime-water, is even greater than it ought to be, if it was exactly proportionate to the evaporation of the water. The cause of which probably is, that the first portions of this matter which crystallize, draw along with them another part that would otherwise have remained dissolved in the water. Hence lime-water, by long exposure to air, loses much of its strength, and at last becomes almost insipid. See a note subjoined to the article QUICK-LIME.

(t) *Hard waters* are those in which soap does not dissolve uniformly, but is curdled. The dissolving power of hard water is less than that of *soft*; and hence its unsuitableness for bleaching, dyeing, boiling leguminous vegetables, and for many other purposes of economy and arts. One cause of the hardness of water is, that it contains some salt that may be decomposed by soap, the alkali of which uniting with the acid of the salt, the oil of the soap separates, and the soap is said to be curdled. Hardness of water proceeding from this cause may be discovered and cured by adding some drops of a solution of fixed alkali. The salts capable of rendering water hard, are not only selenites, which is a very frequent cause of the hardness of water, but any other earthy or metallic salt that may be contained in the water, as all these are capable of being decomposed by fixed alkali. Such are the marine salt with basis of magnesia, or of calcareous earth, vitriolic salt with basis of magnesia called

Epsom salt, green vitriol, and a nitrous salt with earthy basis, to which Dr. Home attributes the hardness of several waters examined by him. The hardness of water has been by some persons attributed to common salt. But Dr. Home in his *Essay on Bleaching* has shewn, that neither pure common salt, nor any other salt with basis of fixed alkali, give any hardness to water, but that this quality may be given to water by the common salt which is generally sold, because this contains some part of the earthy salts of sea-water, or of the water of salt-springs.

Fixable air which waters frequently contain, is another cause of the hardness of water. This air unites with the alkali of soap, renders it mild, and thus weakens its union with the oil. See AIR FIXABLE, and ALKALI (FIXED). This fixable air, by exposure of the water during some time in open vessels, exhales; by which means, water is rendered soft, and any calcareous earth

DCCXXX. **W A T E R (MERCURIAL).** This name is given to a solution of mercury in nitrous acid, diluted with a greater or less quantity of common water.

This liquor produces very good effects, as an escharotic, and even as a caustic in some diseases of the skin that are external, local, and especially venereal. Some persons use this mercurial water internally; but as it must be a dangerous remedy, it ought not to be employed.

DCCXXXI. **W A T E R S (MINERAL).** All waters naturally impregnated with any heterogeneous matter which they have dissolved within the earth may be called *mineral waters*, in the most general and extensive meaning of that name; in which are therefore comprehended almost all those that flow within, or upon the surface of the earth: for almost all these contain some earth or selenites. But waters containing only earth or selenites are not generally called *mineral*, but *hard* or *crude waters*.

Hard waters, when tried by the chemical proofs hereafter to be mentioned for discovering the nature of mineral waters, shew no marks of an acid or of an alkali, nor of any volatile, sulphureous, or metallic matters. Waters which contain a disengaged calcareous earth, change the color of syrup of violets to a green; and those that contain selenites, being mixed with a solution of mercury in nitrous acid, form a turbid mineral; and when a fixed alkali is added, they are rendered turbid, and a white sediment is precipitated. These waters also do not dissolve soap well. From these we may know, that any water which produces these effects is a hard, earthy, or selenitic water.

Although the waters of the sea, and saline springs, be not generally enumerated amongst mineral waters, they might nevertheless be justly considered as such. For besides earthy and selenitic matters, they also contain a large quantity of mineral salts. We shall therefore consider them as such in this article.

Mineral waters, properly so called, are those in which spirituous, sulphureous, saline or metallic substances are discovered by chemical trials. As many of these waters are employed successfully in Medicine, they are also called *medicinal waters*.

or iron which may be dissolved in the water merely by means of this air, as Mr. Caven-  
dish and Mr. Lane have shewn [*Philos.  
Transf.* 1767 and 1769.] are precipitated.

By boiling, the hardness of water proceeding from fixable air may be cured, but that from earthy or metallic salts cannot.

Spring-waters are frequently hard. River water is generally soft. The small quantity of earthy salts contained in rain and snow waters, according to Mr. Margraaf's analysis, does not sensibly render them hard.

As rivers are formed by the junction of many springs, the greater hardness of the

water of the latter seems to be not easily explicable. Does this difference betwixt these two waters proceed from fixable air being contained more copiously in springs, than in rivers, by the motion and free exposure of which it is mostly exhaled? or from a larger quantity of atmospherical air being contained in the water of rivers by means of their motion and free exposure, than in the water of springs; as a mixture of atmospherical air with water is known to encrease the dissolving power of this liquid? or from both these causes united?

Mineral waters receive their peculiar principles by passing through earths containing salts, or pyritous substances that are in a state of decomposition. See PYRITES.

Some of these waters are valuable from the quantity of useful salts which they contain, particularly of common salt, great quantities of which are obtained from these waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that salt only which is most valuable in commerce. See WATER of the SEA; and WATER of SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters consist, ought to be carefully examined. Many of these waters have been accurately analysed by able chemists and physicians.

But notwithstanding these attempts, we are far from having all the certainty and knowledge that might be desired on this important subject; for this kind of analysis is perhaps the most difficult of any in chemistry.

Almost all mineral waters contain several different substances, which being united with water may form with each other numberless compounds. Frequently some of the principles of mineral waters are in so small quantity, that they can scarcely be perceived; although they may have some influence on the virtues of the water, and also on the other principles contained in the water.

The chemical operations used in the analysis of mineral waters, may sometimes occasion essential changes in the substances that are to be discovered. And also, these waters are capable of suffering very considerable changes by motion, by rest, and by exposure to air.

Probably also the variations of the atmosphere, subterranean changes, some secret junction of a new spring of mineral or of pure water; lastly, the exhaustion of the minerals whence waters receive their peculiar principles, are causes which may occasionally change the quality of mineral waters.

We need not therefore wonder that the results of analyses of the same mineral waters made by different chemists, whose skill and accuracy are not questioned, should be very different.

The consequences of what we have said on this subject are, that the examination of mineral waters is a very difficult task; that it ought not to be attempted but by profound and experienced chemists; that it requires frequent repetitions, and at different times; and lastly, that no fixed general rules can be given concerning these analyses.

As this matter cannot be thoroughly explained without entering into details connected with all the parts of chemistry, we shall here mention only the principal results, and the most essential rules, that have been indicated by the attempts hitherto made on this subject.

We may admit the division or arrangement of mineral waters into certain classes, proposed by some of the best chemists and naturalists.

Some of these waters are called *cold*, because they are not naturally hotter than the atmosphere. Some of them are even colder, especially in summer.

Those are called *hot mineral waters*, which in all seasons are hotter than the air. These are of various degrees of heat, and some of them are almost as hot as boiling

boiling water. In some mineral waters certain volatile, spirituous and elastic principles may be perceived, by a very sensible piquant taste; this principle is called the *gas* or the *spirit of waters*.

The waters which contain this principle are generally lighter than pure water. They sparkle and emit bubbles, at their spring, but especially when they are shook, and poured from one vessel into another. They sometimes break the bottles containing them, when these are well corked, as fermenting wines sometimes do. When mixed with ordinary wine, they give to it the piquancy and sparkling quality of Champagne wine.

This volatile principle and all the properties of the water dependant upon it are lost merely by exposure to air. The waters containing this principle are distinguished by the name of *spirituous mineral waters*.

Other divisions of mineral waters may be made, relatively to some of their predominant principles. Hence some waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may observe the following rules:

Experiments ought to be made near the spring, if possible.

The situation of the spring, the nature of the soil, and the neighbouring rising grounds ought to be examined.

Its sensible qualities, as its smell, taste, color, are to be observed.

Its specific gravity and heat are to be ascertained by the hydrostatical balance and the thermometer.

From the properties above-mentioned of spirituous mineral waters, we may discover whether it be one of this class. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing some of this water. By shaking the water, any *gas* that it may contain will be disengaged, and will swell the bladder. If the neck of the bladder be then tyed with a string above the bottle, and be cut below this string, so as to separate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Lastly, we must observe the changes that are spontaneously produced upon the water in close and in open vessels, and with different degrees of heat. If by these means any matter be crystallized or deposited, it must be set apart for further examination.

These preliminary experiments and observations will almost certainly indicate, more or less sensibly, something concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We must then proceed to the decomposition of the water either without addition and merely by evaporation and distillation, or with the addition of other substances, by means of which the matters contained in the water may be precipitated, and discovered. It is not material which of these two methods be first practised, but it is quite necessary that the one should succeed the other. If we begin by evaporating and distilling, these operations must be sometimes interrupted, that the several principles which rise at different times of the distillation may be obtained and examined separately, and also to allow the several salts that may be contained, to crystallize by the evaporation and by cold. *See* EVAPORATION, DISTILLATION, and CRYSTALLIZATION.

The



The substances generally found in mineral waters, are almost always combinations of vitriolic acid, and those of marine acid, together with the several matters that these acids are capable of dissolving.

The following combinations of vitriolic acid are found in mineral waters.

1. *Volatile sulphureous acid.* This is seldom found, both because it easily loses its phlogiston, and because it must almost always meet with some substance that it is capable of dissolving.

2. *Sulphur.* This is found sometimes singly, but generally in form of a liver of sulphur. In these waters, sulphur is formed into a hepar by means of calcareous earth, or of mineral alkali.

3. *Vitriolic salts with earthy bases.* These salts are almost always *selenitic*, that is, their acid is combined with a calcareous earth. Sometimes, but not so frequently, they are *aluminous*, when their acid happens to be united with an argillaceous earth.

4. *Vitriols.* *Martial vitriol* is frequently contained in mineral waters; *vitriol of copper* is sometimes but seldom, and *vitriol of zinc* is still more rarely found in these waters. The vitriols of other metallic substances are scarcely ever, but in very singular cases, found in water.

5. Lastly, *vitriolic salts with basis of fixed alkali.* This is always *Glauber's salt*. Neither *vitriolated tartar* nor *vitriolic ammoniacal salt* are ever found, unless by some singular accident, in mineral waters.

The combinations of marine acid that are contained in mineral waters are *common salt*, and *marine salt with earthy basis*. For no combinations of this acid with phlogiston are known, and it is very seldom found united with any metallic substance.

Compounds formed of the nitrous acid are, in a manner, substances extraneous to the mineral kingdom, since this acid is never produced but upon the surface of the earth, and from vegetable and animal matters. See ACID (NITROUS) and NITRE. This acid cannot therefore be found in waters but very accidentally.

These are the principal substances that form almost all these waters. We shall now shew the proofs by means of which they may be discovered in water, without decomposing the water by evaporation or by distillation.

If any portion of disengaged acid or alkali be contained in water, it may be known by the taste, by changing the color of violets or of turnsol, and by adding the precise quantity of acid or of alkali that is necessary for the saturation of the contained disengaged saline matter.

Volatile sulphureous acid, sulphur, and liver of sulphur, may be discovered in waters by their singular smell, by the black color which these substances give to white metals or to their precipitates, but especially to silver.

Vitriolic salts with earthy basis may be discovered in water by two proofs: 1. By adding some fixed alkali, which decomposes all these salts, and precipitates their earthy basis; and, 2. By adding a solution of mercury in nitrous acid, which also decomposes these salts, and forms a *turbid mineral* with their acid.

*Martial vitriol* or iron combined with any acid, shews itself in waters by blackening an infusion of galls, or by forming a Prussian blue with the phlogisticated alkaline lixivium.

The vitriol of copper, or copper dissolved by any acid, may be discovered by adding some of the volatile spirit of sal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the surface of which the copper is precipitated in its natural or metallic state.

Glauber's salt is discovered by adding a solution of mercury in nitrous acid, and forming with it a turbith mineral; or by crystallization.

Common salt contained in waters forms with a solution of silver in nitrous acid a white precipitate, or luna cornea. It may also be known by its crystallization. Marine salt with earthy basis produces the same effect upon solution of silver. It also forms a precipitate when fixed alkali is added. The acrimony, bitterness, and deliquescentcy of this salt serve to distinguish it.

The proofs related for the examination of mineral waters are only those which are most essential. Many others may be made to confirm the former proofs: but the details of these are too extensive to be inserted here. We shall add only two of these, because they are very general, and may be very useful.

The first is the production of artificial sulphur, or of the volatile sulphureous acid; by which means the vitriolic acid may be discovered in any combination whatever. For this purpose the matter to be examined must be mixed with any inflammable substance, and exposed to a red heat. If this matter contained but a particle of vitriolic acid, it would be rendered sensible by the sulphur, or by the volatile sulphureous acid thence produced. See SULPHUR.

The second general proof for mineral waters which we shall mention here serves to discover any metallic substance whatever, dissolved in water by any acid. This proof consists in adding some of the liquor saturated by the coloring matter of Prussian blue, discovered and described by Mr. Macquer in his Memoir upon Prussian Blue. This liquor produces no effects upon any neutral salts with earthy or alkaline bases, but decomposes all metallic salts: so that if no precipitate be formed upon adding some of this liquor, we may be certain that the water does not contain any metallic salt; and on the contrary, if a precipitate is formed, we may certainly infer that the water does contain some metallic salt.

Two kinds only of *gas*, or the spirituous volatile part of some waters, are hitherto known; of which one is the volatile sulphureous acid, and the other is pure air, as Mr. Venel has shewn in the waters of Sel or Selters. Air united superabundantly with spirituous waters is the chief cause of their lightness, piquancy, and sparkling.

When the nature and quantities of the principles contained in a mineral water are ascertained by suitable experiments, it is very proper to attempt to imitate artificially this water, by adding to pure water the same proportions of the same substances, as Mr. Venel has done in examining several waters, especially that of Selters.

We may easily perceive the necessity of using no vessels in these experiments, but such as are perfectly clean and rinsed with distilled water; of weighing the products of the experiments very exactly; of making the experiments upon as large quantities of water as is possible, especially the evaporations, crystallizations, and distillations; and of repeating all experiments several times. We may further observe, that the mixtures from which any precipitates might be expected,

expected, ought to be kept two or three days, because many of these precipitates require that time or more to appear, or to be entirely deposited.

We shall now endeavor to explain how mineral waters become impregnated with their principles.

The *selenitic* parts of water are received by this fluid while it flows through gypseous earths and stones, these being composed of selenites, which is soluble in water.

The mines of sal gem which are in many places, and particularly where salt-springs are, furnish the waters which flow through them, and perhaps the sea itself, with the *common salt* that they contain.

When a water once contains common salt, it may become impregnated with *Glauber's salt* by passing through clay; the vitriolic acid that is always contained in argillaceous earths, decomposing a part of the common salt of the water, with the basis of which it forms the Glauber's salt; while the marine acid now disengaged will unite with the first calcareous particles that it meets, and form a *marine salt with earthy basis*, which is accordingly always found in sea-water, and in salt-springs.

When water impregnated, or not, with saline principles flows through parts of the earth containing pyrites in a state of decomposition, it becomes impregnated with *sulphur*, with *marial vitriol*, with *vitriol of copper*, with *alum*, and with *other salts*; and frequently with several of these substances at the same time, according to the nature of the pyrites. See PYRITES.

The *heat of hot mineral waters* can be only acquired by washing large masses of pyrites and other similar minerals in a state of spontaneous decomposition, during which they always acquire considerable heat.

Lastly, the *aerial gas* of some mineral waters may have been discharged from some of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were dissolved by the water, or which were combined after this solution. For we know that in almost all solutions much air is extricated; and this air being well divided and diffused among the particles of water, adheres to them, and in some measure combines with them superabundantly. Mr. Venel has made upon this subject a fine experiment, that proves the truth of the above-mentioned theory, which was first given by him. He added to common water as much marine acid and mineral alkali as were sufficient to form as much common salt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded slowly and without effervescence, because the saline matters were much diluted; and when the combination was completed, the artificial water was become spirituous and aerial, like the natural water that he imitated. See the particular articles of all the substances mentioned that relate to mineral waters; from a knowledge of the properties of which substances many explanations on this subject may be deduced, too long to be here inserted. (u)

(u) The gas which gives the sparkling and inebriating qualities to many mineral waters, seems not to differ from the vapor extricated from effervescing and fermenting substances,

called *fixable air*. See AIR (FIXABLE). The Honourable Mr. Cavendish has added to his former important discoveries concerning fixable air, one that throws much light on the nature

DCCXXXII. W A T E R S (M O T H E R). This name is given to the liquor that remains after as much of the saline substances contained in a water has been separated as can be by the usual methods, evaporation and cooling, and from which therefore no more crystals can be obtained, without much difficulty, though it still remains impregnated with salts. These mother-waters are very different, according to the kinds of salts with which the waters were originally impregnated. They are generally very heavy, acrid, and red.

The nature of mother-waters was a long time very imperfectly understood. They were considered as liquors loaded with greasy and viscid matters, by means of which the salts contained were prevented from crystallizing.

A portion of crystallizable salt, similar to those already extracted, does indeed remain in the mother-waters; and perhaps also the crystallization of these may be impeded by the viscid matters that are sometimes contained in these waters: but generally the greatest part of the matter contained in mother-waters is

nature of many mineral waters. This discovery is, that by means of fixable air, and without the intervention of any acid, calcareous earth is dissolved in some mineral waters. He found that the quantity of this air that was contained in Rathbone-place-water, relatively to the quantity of calcareous earth contained in that water, was about twice as much as is usually combined with an equal quantity of calcareous earth; and that the earth might be precipitated from this water by driving off the fixable air by heat, or by absorbing it by the addition of lime-water. Does not this solution of calcareous earth by fixable air confirm a conjecture concerning the analogy of this vapor with acids? It seems very extraordinary that calcareous earth saturated with its usual quantity of air should be insoluble in water, but that it may be rendered soluble, either by depriving it entirely of this air, as it is in lime-water, or by uniting it with a superabundant quantity of air, as it is in the water of Rathbone-place. See *Phil. Transf. for the Year 1767*.

Mr. Lane has discovered another instance of the dissolving power of fixable air upon iron, and has, by some ingenious experiments, shewn the probability that this metal is dissolved in many mineral waters by means only of that air. He found that pure distilled water, having been impregnated with the fixable air arising from effervescing or fermenting substances, was rendered capable of dissolving a sensible portion of iron; and that this artificial chalybeate water, by exposure to air, lost entirely its property of tinging an infusion of galls. As several

chalybeate mineral waters do also, by exposure to air, entirely lose their property of tinging an infusion of galls; and as waters containing iron dissolved by means of vitriolic acid, though a considerable sediment is also deposited from them, do never entirely lose this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this air. He further shews, from experiments, that iron cannot be so entirely precipitated from its solution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this solution shall lose its power of tinging an infusion of galls; but that the iron may be so perfectly precipitated from the above-mentioned solutions by means of caustic alkali, or of lime-water; and hence he infers, that in the former case the portion of iron that is not precipitated is kept suspended or dissolved by means of the fixable air extricated by the acid of the solution from the mild alkali or earth. See *Phil. Transf. for the Year 1769*.

In the above article concerning mineral waters, the Author of the Dictionary considers nitre or nitrous acid as substances not to be found in native waters, but by some accidental occurrence. Nevertheless, from the experiments of Mr. Margraaf on the waters of the wells at Berlin, of Dr. Heberden on those of London, and of Dr. Home on those of some wells in Scotland, we have reason to believe, that true nitre and a nitrous salt with earthy basis are frequently contained in waters of springs, especially in towns.

composed of salts that are deliquescent and different from those already obtained by crystallization. We are certain, at least, that the mother-waters of sea-salt and of nitre are formed almost entirely of these salts, which have a certain kind of adhesion to the crystallizable salts, and which therefore prevent the crystallization of the last portions of these. The mother-water of common salt contains a considerable quantity of marine salt with earthy basis, and the mother-water of nitre contains not only marine salt with earthy basis, but also a considerable quantity of nitre with earthy basis: hence, if a fixed alkali be added to these waters, a white earthy precipitate is formed so copiously, that the whole becomes a kind of paste. By diluting this paste with much water, the earth may be obtained by filtration. The earth whenedulcorated is very white, and of a calcareous nature. It is called *magnesia*. (\*)

If vitriolic acid be added to these mother-waters, a very copious white precipitate is likewise formed. This precipitate also proceeds from the union of this acid with the calcareous earth of the earthy salts, by which a selenites is formed. This selenites, not being soluble in so small a quantity of water as that of the mother-water employed, is mostly precipitated in form of an earthy sediment consisting of very minute crystals. See SALTS with EARTHY BASIS, and MAGNESIA.

DCCXXXIII. W A T E R of R A B E L. The water of Rabel is vitriolic acid dulcified by mixture with rectified spirit of wine. Rabel, the inventor of this liquor, which is used in medicine, employed an expensive apparatus in the preparation of it. He obtained the vitriolic acid from pyrites: but since his time, the process has been much simplified, as it ought to be. One part of oil of vitriol is mixed with three parts of rectified spirit of wine, and the mixture is digested in a well-closed vessel. The vitriolic acid acts upon all the principles of the spirit of wine, and combines with them in a certain degree during this digestion: hence the acidity of the liquor is considerably diminished, but not perfectly destroyed. This water of Rabel may be considered as a dulcified vitriolic acid. See ETHER.

Water of Rabel is employed in medicine as an astringent, from the property which the vitriolic acid has of constringing the fibres and vessels. It requires to be diluted in some proper vehicle, as in potions or juleps.

DCCXXXIV. W A T E R (S E A). Sea-water, and the waters of many salt-lakes, wells, and springs, containing various kinds of salts, is in much greater quantity than fresh-water.

We may say in general, that all natural salt-waters contain four kinds of salts, namely, common salt, Glauber's salt, selenites, and marine salt with earthy basis. These salts are in different quantities and proportions, according to the nature of the waters; but the quantity of the common salt is always greater than that of any other.

(\*) *Magnesia* is an earth not convertible into quicklime, therefore different from calcareous earth, with which the Author of the Dictionary confounds it, and is possessed of peculiar properties. See the article MAGNESIA, and the NOTE subjoined.

The mother-waters of common salt and of nitre do also contain some marine and nitrous salts with basis of calcareous earth, as appears from the formation of selenites upon adding vitriolic acid, as is mentioned in the following paragraph of the text.

All these waters have a saline, and more or less of an acrid, bitter taste. The acrimony and bitterness of these waters are generally attributed to bituminous matters supposed to be contained in them: but I can affirm, that I have made many experiments on large quantities of these several waters, and that I could never find any sensible quantity of bitumen. The bitterness, therefore, of these waters ought to be attributed to the Glauber's salt, which is bitter, and especially to the marine salt with earthy basis, which is very bitter and acrid.

Sea-water is not every-where impregnated with an equal quantity of salt. Generally, it has been observed to contain more salt in hot than in cold climates. The quantity of common salt contained in sea-water is to the quantity of that water as three or four to a hundred. The water is consequently far from being saturated with that salt; for water is capable of dissolving nearly a fourth part of its weight of common salt.

Common salt is obtained from sea-water by evaporation alone, and not by alternate evaporation and cooling; because this salt is equally soluble in cold as in hot water. See CRYSTALLIZATION, and SALT (COMMON).

In the southern provinces of France, and in all equally hot or hotter climates, sea-water is evaporated in open air, and merely by the heat of the sun in summer, by which means the common salt is obtained. For this purpose, large basins are made in the ground near the sea, called salt-marshes. They are so disposed that the sea-water may flow into them at certain tides, and be retained there. These marshes are divided into many compartments, communicating with each other, into which any required quantity of water may be admitted. The water in these is of a small depth, that the evaporation may advance more quickly. When the water is sufficiently evaporated, and the salt is crystallized, more water is admitted, till a sufficient quantity of salt is obtained, which is then gathered in heaps and drained.

In the northern provinces of France common salt is obtained from sea-water in the following manner:

A quantity of sand moistened with sea-water is exposed to the sun and dried, which is quickly done, because the sea-water is almost entirely near the surface of the sand. The sand, which then becomes covered with a considerable quantity of salt, is to be washed with as much water as is necessary for the solution of the salt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the salt is crystallized.

Wallerius says, that in northern countries the salt in sea-water is concentrated by exposure to intense cold, by which great part of the water is frozen, and the unfrozen part, which contains almost all the salt, is afterwards evaporated by fire, till the salt is crystallized.

After the common salt has been thus obtained by these operations from sea-water, a liquor, called *mother-water*, remains that contains much salt, which cannot be crystallized. If this water be further evaporated, and then exposed to cold, a certain quantity of Glauber's salt will be formed, which is very impure and badly crystallized, and is generally called *Epsom salt*. See SALT (EPSOM). (y)

(y) The salt called *Epsom salt*, or sal catharticus amarus, large quantities of which are obtained from the mother-water remaining after the evaporation of sea-water, and which

Lastly, the remaining part of the mother-water contains scarcely any thing but marine salt with earthy basis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magnesia of common salt*. See WATER (MOTHER), and MAGNESA.

DCCXXXV. WATER of SALT - SPRINGS. The water of almost all salt springs, at least of those from which common salt is obtained, contains exactly the same principles as sea-water, but generally in a larger quantity. Some of these springs contain sixteen pounds of salt in a hundred pounds of water. Such, for instance, is that of Dieulieu in Lorraine, one of the best salt-works known. Other springs contain a much smaller proportion of salt; such is that of Montmorot in Franche-comté.

Salt is obtained from these salt-springs generally by evaporation over the fire; at least, it is so in Lorraine, and in Franche-comté: but that the expence of fuel may be lessened, the water, when weakly impregnated, is previously concentrated by frequently pouring it upon bundles of twigs or taggots under buildings that are covered, but open at all the sides, called *graduating houses*. The water raised by pumps to the top of these buildings falls upon the taggots, by which it is divided into a shower, its surface is thereby encreased, and the evaporation is promoted by the free current of air that passes through the open sides of the building. When, by this means, the water is so concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of salt, it is then evaporated over the fire in the usual manner.

As these waters are much more impregnated with saline principles than sea-water, and as their evaporation is more quickly finished, we shall confirm what we have said concerning the evaporation and formation of the several salts in sea-water, by describing the method employed in the evaporation of the water of the salt-springs of Lorraine and Franche-comté.

This water is evaporated in very large vessels made of plates of iron, capable of containing from eight to nine or ten thousand gallons of water, called *salt-pans*, the depth of which is about fifteen or sixteen inches.

In these the water is boiled some time, during which a saline earthy matter, called *schlot or scratch*, is deposited, and is carefully to be separated. This scratch is a selenites, which of all the saline matters contained in the water is the least soluble, and consequently crystallizes first. This selenites draws along with it some of the other salts, and principally Glauber's salt, which seems to have some degree of adhesion to it.

When the selenites is separated, the common salt, being in greater quantity than the other salts, begins to crystallize and form cubes. That larger crystals of this salt may be formed, the water is made to boil very slowly, till the common salt ceases to crystallize. The water that remains is very heavy, much impregnated with salt, of an acrid and bitter taste. This is the *mother-water*.

This mother-water contains still some common salt, some Glauber's salt, and especially a large quantity of marine salt with earthy basis. The Glauber's

which is similar to the salt obtained by evaporation of the mineral water at Epsom, is composed of vitriolic acid and magnesia; it is therefore improperly said to be Glauber's

salt, which consists of vitriolic acid united with mineral alkali, although some of this latter salt also is said to be contained in sea-water.

salt remains chiefly in the mother-waters, because it is much more soluble in hot than in cold water, and crystallizes more readily by cold than by evaporation. The marine salt with earthy basis remains almost entirely in the mother-water, because it is deliquescent, and not susceptible of a true crystallization. *See WATER (MOTHER).*

The several salts contained in waters of salt-springs are thus separated from each other: but this separation is not very accurate. To render it more complete, other means must be employed. The fundamental principles of the perfect purification of the several salts confounded together in the same water are explained at the article CRYSTALLIZATION. To avoid repetitions, we refer to that article. *See also the articles SELENITES, SALT (COMMON), SALT of EPSOM, SALT of GLAUBER, SALT (MARINE) with EARTHY BASIS, WATER (MOTHER), and WATERS (MINERAL).*

DECCXXXVI. W A X. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long considered as a resin, from some properties common to it with resins. It has the same consistence as resins have, and, like them, it furnishes an oil and an acid by distillation, and is soluble in all oils: but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and, when pure, no taste. With the heat of boiling water no principles are distilled from it; whereas, with that heat, some essential oil, or, at least, a spiritus rector is obtained from every resin. Further, wax is insoluble in spirit of wine. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied with a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence be such that it becomes solid in the receiver, and is then called *butter of wax*. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible from the want of some saline matter. *See COAL.*

Wax cannot be kindled, unless it be previously heated and reduced into vapors; in which respect it resembles fat oils. The oil and butter of wax may, by repeated distillations, be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes: but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in spirit of wine; and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years; without acquiring a more solid consistence. We may remark, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above-mentioned properties, and that in all these they perfectly resemble sweet oils. *See OILS (ESSENTIAL), RESINS, and OILS (SWEET EXPRESSED).*

We may therefore conclude from what has been said, as Mr. Macquer has done in his Elements of Chemistry, and in his Memoir upon Oils, that wax  
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only resembles resins in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which in resins is of the nature of essential oils, while in wax and in other analogous oily concretions, (as butter of milk, butter of cocoa, fat of animals, spermaceti, and a wax obtained from a tree in Louisiana) it is of the nature of sweet, unctuous oils that are not aromatic and not volatile, and are obtained from vegetables by expression.

Wax is very useful, especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeable color, and be perfectly whitened, by exposure to the united action of air and of water, by which method the color of many substances may be destroyed.

The art of bleaching wax consists in encreasing its surface. For which purpose, it must be melted with a degree of heat not sufficient to alter its quality, in a cauldron so disposed that the melted wax may flow gradually through a pipe at the bottom of the cauldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half; and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favorable, the color will be changed in the space of some days. It is then to be re-melted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax be rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow color of the wax is evidently destroyed by the combined action of the air, of the water, and of the sun. As the volatile, sulphureous acid has the property of destroying still more quickly almost all the colors of vegetables, perhaps this bleaching might be shortened by exposing ribbands of yellow wax to the vapor of sulphur, as is practised for wool and silk.

Every kind of wax is not equally capable of being whitened, the color of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation I have received from Mr. Trudon, proprietor of the manufactory of wax, at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy; but it is only used externally, mixed with other substances. It is an ingredient in many pomatums, cerates, ointments, and plasters, to most of which it gives the due consistence. Upon this subject may be consulted Mr. Beaumé's Elements of Pharmacy, a work containing many excellent observations.

DCCXXXVII. W H E Y. See MILK.

DCCXXXVIII. W H I T E (S P A N I S H). This name is given to very different substances, namely, the *magistery of bismuth*, and the washed *chalk* used for painting in water colors.

DCCXXXIX. W H I T E - L E A D. This name is given to the white rust produced by exposing lead to the vapors of vinegar. It is also called *ceruss*. See CERUSS.

DCCXL. W I N E. Chemists give the name of *wine* in general to all liquors that have become spirituous by fermentation. Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and other similar liquors, are wines.

The principles and theory of the fermentation which produces these liquors are essentially the same. The more general principles we have explained under the article FERMENTATION. At the articles BEER and HYDROMEL may be found some peculiarities relative to these kinds of wines. In the present article we shall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the same time, we shall not neglect any thing relating to spirituous fermentation in general.

All vegetable and animal matters, which have a taste sweet, agreeable, and more or less saccharine, and which are nutritive, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is possessed of the above-mentioned qualities; and, lastly, it may be made of all ripe succulent fruits, which also are possessed of these qualities: but all these substances are not equally proper to be changed into a good and generous wine.

As the production of ardent spirit is the result of the spirituous fermentation, we may consider that wine as essentially the best which contains most of this spirit. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines that have a more agreeable, that is, more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least, from these latter wines the best vinegar and aqua vitæ are made. As an example therefore of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

This juice, when newly expressed, and before it has begun to ferment, is called *must*, and in common language *sweet wine*. It is turbid, has an agreeable and very saccharine taste. It is very laxative, and when drunk too freely, or by persons disposed to diarrhæas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried.

When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature from ten or twelve degrees to fifteen or sixteen, very sensible effects are produced in it, in a shorter or longer time, according to the nature of the liquor, and the temperature of the place. It then swells, and is so rarefied, that it frequently overflows the vessel containing it, if this be  
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nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise and evident ebullition. The bubbles rise to the surface, and, at the same time, is disengaged a vapor which is probably of a phlogistic nature, and is so subtle and dangerous, that it is capable of killing instantly men and animals exposed to it in a place where the air is not renewed. In its effects this vapor is similar to that of burning charcoal. The skins, stones, and other grosser matters of the grapes, are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a scum or soft and spongy crust that covers the whole liquor. During the fermentation this crust is frequently raised, and broken by the air disengaged from the liquor, which forces its way through it: afterwards the crust subsides, and becomes entire as before.

These effects continue while the fermentation is brisk, and at last gradually cease: then the crust being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopt. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place.

After this first operation, nature tends spontaneously to a kind of rest, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drank moderately.

If we examine the wine produced by this first fermentation, we shall find that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of must, but affects the head, and occasions, as is well known, drunkenness. Lastly, if it be distilled, it yields, instead of the insipid water obtained from must by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor called *spirit of wine*, or *ardent spirit*. This spirit is consequently a new being, produced by the kind of fermentation called the *vinous* or *spirituous*. See SPIRIT (ARDENT).

As, on one side, the liquors susceptible of the spirituous fermentation contain chiefly a sweet oil rendered miscible with water by means of an acid; and as, on the other side, the liquor produced by the spirituous fermentation is inflammable, but still miscible with water, and consequently composed of a watery and inflammable principle; we may easily perceive, that the work of nature chiefly consists in attenuating, dividing, and volatilising the oily parts of fermentable matters, and in combining these intimately with the watery principle. But by what mechanism does nature operate this change? In what does this attenuation of the oily part precisely consist? In what proportion is this oil, or only its inflammable principle, united with the watery principle in the composition of ardent spirit? These are mysteries of nature that are still entirely hid from us, and which we cannot easily explain. Without entering, therefore, into a speculation concerning the production of ardent spirit, we shall proceed in the history of spirituous fermentation.

When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time, otherwise the fermentation would probably be very quickly compleated, and the appearances would be much more striking: hence,

hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous than in another liquor less disposed. Experience has shewn, that a wine, the fermentation of which is very slow and tedious, is never good and very spirituous; and therefore, when the weather is too cold, the fermentation is usually accelerated by heating the place in which the wine is made. A proposal, which I think is a good one, has been made by a person very intelligent in economical affairs, to employ a greater than the usual heat to accelerate the fermentation of wine, in those years in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation.

A too hasty and violent fermentation is perhaps also hurtful, from the dissipation and loss of some of the spirit: but of this we are not certain. However, we may distinguish, in the ordinary method of making wines of grapes, two periods in the fermentation, the first of which lasts during the appearance of the sensible effects above-mentioned, in which the greatest number of fermentable particles do ferment. After this first effort of fermentation, these effects sensibly diminish, and ought to be stopped, for reasons hereafter to be mentioned. The fermentative motion of the liquor then ceases. The heterogeneous parts that were suspended in the wine by this motion, and which render it muddy, are separated, and form a sediment called the lees; after which the wine becomes clear: but although the operation be then considered as finished, and the fermentation apparently ceases, it does not really cease; and it ought to be continued in some degree, if we would have good wine. In this new wine a part of the liquor remains that has not fermented, and which does afterwards ferment, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation, therefore, continues still in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the *imperceptible fermentation*. We may easily perceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of spirit in wine. It has also another effect no less advantageous, namely, the separation of a saline, acid, earthy matter, called *tartar*, from the wine. This matter is therefore a second sediment that is formed in the wine, and which adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident that the wine, which, by means of the insensible fermentation, has acquired more spirit, and has disengaged itself of the greatest part of its tartar, ought to be much better and more agreeable; and for this reason chiefly, old wine is universally preferable to new wine.

But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation has regularly proceeded, and has been stopped in due time. We know certainly, that if a sufficient time has not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air and vapors that are disengaged during the fermentation. We have an instance of these effects in the white wine of Champagne, and in others of the same

same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known that these wines make the corks fly out of the bottles, that they sparkle and froth when they are poured into glasses, and, lastly, that they have a taste much more lively and more piquant than wines that do not sparkle; but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of air which is disengaged during the confined fermentation which the wine has undergone in close vessels. This air, not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines in some measure with these, and adheres in the same manner as it does to those mineral waters that are called spirituous, in which it produces nearly the same effects. When this air is entirely disengaged from these wines, they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid.

Such are the qualities that wine acquires in time, when its first fermentation has not continued sufficiently long. These qualities are given purposely to certain kinds of wine, to indulge taste or caprice; but such wines ought not to be daily drank. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation should be insensible, or, at least, exceedingly little sensible. Wine, in which the first fermentation has been too far advanced, is liable to worse inconveniences than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is from its nature in a continual fermentative motion, more or less strong, according to circumstances, from the first instant of the spirituous fermentation, till it is completely putrefied: hence from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very slow and insensible when the wine is included in very close vessels, and in a cool place; but it does gradually advance, so that in a certain time the wine, instead of being meliorated, becomes at last sour. This evil cannot be remedied, because the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become sour, can only conceal or absorb this acidity by certain substances, as by alkalis and absorbent earths. But these substances give to wine a dark-greenish color, and a taste, which, though not acid, is somewhat disagreeable. Besides, calcareous earths accelerate considerably the total destruction and putrefaction of the wine. Calxes of lead, having the property of forming with the acid of vinegar a salt of an agreeable saccharine taste, which does not alter the color of the wine, and which besides has the advantage of stopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occasion most terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, should, for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners and murderers of the public.

If wine contains litharge, or any other calx of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small regulus of lead may be found after the fusion.

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but an easier and more expeditious proof is by pouring into the wine some liquid liver of sulphur. If the precipitate occasioned by this addition of the liver be white, or only colored by the wine, we may know that no lead is contained: but if the precipitate be dark-colored, brown, or blackish, we may be certain that lead is contained.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is but very little acid; and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what we have said concerning the acescency of wine we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do. We may observe, that the first sensible fermentation having been too far advanced, is not the only cause of the acidity of wine, but that heat also is capable of producing the same effect. Thus wine, which might have been long preserved in a cool place, very quickly becomes sour, when placed in a bad cellar; and even as the best cellars have during winter a degree of heat much superior to that of the atmosphere, it would be very proper, when wine disposed to become sour is to be preserved, to bring it from the cellar in the beginning of winter, and leave it exposed to the air during all that season.

Wine is also liable to other changes; as, to become rosey and mucilaginous, by the continuance of the fermentative motion: but we cannot prosecute these details in a work of this kind. Besides, the spirituous fermentation and its consequences still require a further examination, which we hope will be performed in a satisfactory manner, since several Academies, sensible of the importance of the subject, have offered prizes for discoveries relative to it. All that we can at present say is, that the fundamental principles from which we may deduce a more accurate knowledge on this subject, may be discovered by determining with what degree of heat, and during what time, the first sensible fermentation of must ought to be promoted, that the most spirituous and best-keeping wine may be obtained. I confess that this object is very extensive, and very difficult to be known in a general manner, considering how variable these things are, and what differences, perhaps greater than we now imagine, there ought to be, according to the nature of the must, which varies exceedingly in different countries, and at different times. Experience and observation have already instructed makers of wine in many things relative to this subject; but much yet remains to be determined, which is not within the reach of ordinary country-people, or even of the proprietors of the great vine-yards.

Wine, and the matters produced from wine, as brandy, spirit of wine, vinegar, lees of wine, tartar, are greatly and extensively useful. The lees of wine are employed in the manufacture of hats. These lees, and also tartar by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali. See the articles *AQUA VITÆ, SPIRIT of WINE, TARTAR, and VINEGAR.*

Wine has been preferred in all times and<sup>1</sup> in all countries to every other alimentary liquor. We may say in general, that it is good and salutary when taken in small quantities, and that it is pernicious when drank habitually, and in too large quantities. Wine becomes then a true slow poison, which is so much more dangerous, as it is more agreeable. But if we observe more particularly the effects of wine, we shall perceive very great differences depending on different constitutions. Some persons drink habitually large quantities of pure wine, without any sensible inconvenience, or disease, or shortening their lives: but, on the contrary, many others do also entirely destroy their health, and shorten their lives, by an habitual use of wine even in small quantity, and mixed with water. Although it is always more safe and prudent for every person to drink little of it habitually, this moderation is more indispensably necessary to those whose constitutions wine does not suit.

As the diseases consequent upon the too free use of wine come gradually and insensibly, sometimes even during many years, several persons, especially men, otherwise very sober and attentive to health, are every day deceived upon this article, drinking more wine than is suitable to their constitution, and gradually ruining their health without knowing the cause. It is therefore a matter of importance to shew the signs by which wine may be known to be hurtful. We may know that wine does not suit a person, when, after drinking moderately of it, his breath acquires a vinous smell; when it occasions sour belchings and slight pains in the head; and when, after drinking it more copiously than usual, it produces stupefaction, nausea, and drunkenness, especially when this drunkenness is of the morose, peevish, quarrelsome, and irascible kind. Unhappy is that person who suffers these effects from wine, and notwithstanding contracts and persists in the habitual use of it. These imprudent persons do never fail of coming to a miserable death, preceded by languor, and premature; their common age being about fifty years, or a little more. The diseases to which they are most subject are obstructions in the liver, in the mesenteric glands, and in other abdominal viscera, which are almost always succeeded by an incurable dropsy. Those who digest wine well, do not suffer, or much less sensibly, the above-mentioned effects of drinking it. Their drunkenness is accompanied with vivacity and joy. Such persons seldom die of the obstructions and dropsy above-mentioned: but wine is nevertheless so much more dangerous to them, that as they suffer none of the disagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this class generally live somewhat longer than the former; but their constitution generally changes before sixty years of age; and the inheritance of their old age is either a severe gout or palsy, stupidity, imbecillity, or an accumulation of these diseases.

We need not mention that the too frequent use of brandy, ratafia, and of other spirituous liquors is still much more pernicious and fatal than of wine.

Wine is used in medicine as a vehicle in the composition of many internal and external remedies. As wine is composed of an ardent spirit, water, extractive saponaceous matter, and acid of tartar, it may be very usefully employed for the extraction of almost all the proximate principles, and consequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be considered as being more compleat than those made with water: but physicians who prescribe these extracts ought to remember that, besides the

the principles of the vegetables, they also contain the extractive part of wine, that is, all the principles of wine, excepting the ardent spirit, which is too volatile to remain in an extract.

Wine, when good, may be preserved during a long time, several medicinal wines prescribed in dispensaries are kept in the shops of apothecaries. Such are the astringent, antiscorbutic, febrifugal wines of the Peruvian bark, of wormwood, chalybeate wine, and others. In many cases, as in several chronic diseases, where tonic, cordial, fortifying and exciting remedies are indicated, physicians prefer the use of wine to water, as a vehicle for the infusion of purgative, aperitive, and other medicinal substances.

DCCXLI. W O A D. (z)

(z) WOOL. Dr. Lewis in a note to his edition of Neuman's Chemical Works gives the following account of wool.

*Wool, ifatis, glastum*, is a plant with long green leaves; the lower ones narrow at both ends; those which grow upon the stalk are broad at bottom like an arrow-head. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the seeds. It grows wild in some parts of France, and on the coasts of the Baltic Sea: the wild wool, and that which is cultivated for the use of dyers, appear to be the same species of plant. The preparation of wool for dying, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc. The plant puts forth at first five or six upright leaves, about a foot long and six inches broad: when these hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan-mills, and ground into a smooth paste. If this process was deferred for some time, they would putrefy, and send forth an insupportable stench. The paste is laid in heaps, pressed close and smooth, and the blackish crust, which forms on the outside, reunited if it happens to crack: if this was neglected, little worms would be produced in the cracks, and the wool would lose a part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun, they turn black on the outside; in a close place, yellowish, especially if the weather be rainy: the dealers in this com-

modity prefer the first, though it is said the workmen find no considerable difference betwixt the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and when rubbed, of a violet colour within. For the use of the dyer, these balls require a further preparation: they are beat with wooden mallets, on a brick or stone floor, into a gross powder; which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder, moistened with water, ferments, grows hot, and throws out a thick fetid fume. It is shovelled backwards and forwards, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures, of different shades, to water, to rectified spirit of wine, to volatile alkaline spirits, and to fixed alkaline lixivia: rubbed on paper, it communicates a green stain. On diluting the powder with boiling water, and after standing some hours in a close vessel, adding about one twentieth part of its weight of lime newly slaked, digesting in a gentle warmth, and stirring the whole together every three or four hours, a new fermentation begins, a blue froth arises to the surface, and the liquor, though it appears itself of a reddish color, dyes woollen of a green, which, like the green from Indigo, changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

Astruc proposes the manufacturing of fresh wool leaves in Europe, after the same manner as the Indigo plant is manufactured in America;



DCCXLII. W O L F R A M. (a)

DCCXLIII. W O O L (P H I L O S O P H Y C). This is a name given by ancient chemical or alchemical authors to flowers of zinc. See FLOWERS of ZINC.

DCCXLIV. W O R M W O O D. (b)

America; and thus preparing from it a blue fecula similar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtless be accompanied with some advantages, though possibly, woad so prepared might lose those qualities which now render it, in a large business, preferable on some accounts to indigo, as occasioning greater dispatch when once the vat is ready, and giving out its color less hastily, so as to be better fitted for dying very light shades.

(a) WOLFRAM, *Spuma lupi*, is a very refractory mineral of a black or dusky color, crystallized in form of cubes, striæ, or other determinate shape, and consisting of shining plates. Its appearance is similar to the ore

of tin, called tin-grains or crystals of tin: and it is frequently found in tin-mines. It is so hard that it can strike sparks from steel. When powdered, it is red. Wallerius considers it as an ore of iron mineralized by arsenic, which sometimes contains tin. According to Cronstedt, it is a kind of magnesia or manganese, containing a small portion of iron and of tin.

(b) WORMWOOD. The leaves of wormwood are intensely bitter, and have a strong smell, somewhat of the aromatic kind. They yield in distillation a considerable quantity of essential oil of a dark greenish color possessing the whole of their smell, the bitter matter remaining in the extract. *Neuman.*

## Z.

DCCXLV. **Z** A F F R E, or S A F F R E. Zaffre is the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore a kind of calx of cobalt, of a grey or reddish color. The use of cobalt is to produce a very fine blue color, when it is melted with fusible and vitrifiable matters.

This blue color produced by the vitrification of zaffre proceeds from the earth or calx of a semi-metallic substance contained in cobalt, called by chemists, *regulus of cobalt*. This is proved by melting zaffre with a reducing flux, like any other roasted ore; by which means the above-mentioned semi-metallic regulus of cobalt will be obtained. The scoria in this fusion has also a blue color, which proceeds from a portion of the calx of this regulus that is not reduced, but is vitrified along with the scoria.

The calx therefore or metallic earth of the regulus of cobalt is the sole cause of the blue color produced by zaffre. But as the quantity of regulus contained in cobalt is variable, therefore some zaffres furnish more blue than others. The heterogeneous, fixed matters contained in cobalts, contribute, according to their quantity, not only to the greater or less intensity of the blue color, but also to its lustre and beauty. For which reason those who manufacture zaffre from cobalt make frequent essays of the roasted ore by mixing it with vitreous matters to discover the intensity and beauty of the blue color.

Good cobalts calcined would form too deep a blue, and almost a black glass, if they were not previously mixed with a certain quantity of vitreous frit. In the manufacture of zaffre, therefore, the calx of cobalt, the strength of which has been previously determined by Essays, is mixed with such a quantity of sand, or of powdered flints and quartz, that with the addition of some saline flux, a deep blue glass may be formed.

The zaffre that is commonly sold, and which comes from Saxony, is a mixture of calx of cobalt with some vitrifiable earth, as we have said. It is of a grey color,

color, as all calxes of cobalt are before vitrification. Some zaffres are dearer than others, according to the intensity of the color which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the surface of the pieces of ware, upon which it is applied together with some saline flux, previously to the baking or glazing, that the same fire may also vitrify this coloring material.

The blue of zaffre is the most solid and fixed of all the colors that can be employed in vitrification. It suffers no change from the most violent fire. It is successfully employed to give shades of blue to enamels, and to the crystal-glasses made in imitation of some opaque and transparent precious stones, as the lapis lazuli, the turquois, the sapphire, and others of this kind. See the articles AZURE, COBALT, INK (SYMPATHETIC), and SMALT.

#### DCCXLVI. Z E O L I T E S. (c)

DCCXLVII. Z I N C. Zinc is a semi-metal, of a brilliant white color, approaching to blue. It is the least brittle of the semi-metals; and when well furnished with phlogiston, which may be effected by treating it with inflammable matters in a close vessel, it possesses a semi-ductility, by means of which it may be flattened into thin plates. (d).

This property, joined to its hardness, which is also considerable, renders it incapable of being pulverised like the other semi-metals; therefore, when it is required in a divided state, it must be melted and granulated, or filed, like metals.

(c) ZEOLITES. This name is given by Mr. Cronstedt to a stone described by him in the *Transactions of the Academy of Sciences at Stockholm for the year 1756*, the peculiar properties of which have induced that mineralogist to consider it as forming a distinct order of earths, called *zeolites*. The properties of this stone or class of earths, are the following.

1. It is a little harder than the fluors, and calcareous spars. It may be scratched by steel, from which it does not elicit sparks.

2. It may easily be melted by heat without addition, into a white frothy slag, which not without great difficulty can be rendered solid and transparent. Crystallized zeolites, when melted, boils, as borax does.

3. It may be dissolved in the fire more easily by mineral alkali than by borax or by the fusible salt of urine.

4. It does not effervesce with the fusible salt of urine, as calcareous stones do; nor with borax, as gypseous stones do.

5. It dissolves very slowly, and without effervescence, in acids, as in oil of vitriol, and spirit of nitre. When concentrated vitriolic acid is poured on powdered zeolites, a heat arises, and the powder is changed into a gelatinous mass.

6. In the very moment of fusion it gives a phosphoric light.

Zeolites has been found only in an indurated state. It is either, 1. consisting of particles of no determinate form; or, 2. *sparry*; or, 3. *crystallized*.

The zeolites that consists of particles of no determinate form, is either *pure*, and white; or it is *mixed with silver and iron*; which latter kind is of a blue color, and is commonly called lapis lazuli. See LAPIS LAZULI.

The *sparry zeolites* resembles calcareous spar, but is more brittle. This is of a light red, or orange color.

*Crystallized zeolites*. Groupes of crystals of zeolites are found in form of white or yellow balls consisting of many pyramids the apices of which unite in the center; or of white prisms with truncated angles; or of white capillary crystals.

Zeolites has in the fire nearly the same properties as boles have. See *Stockholm Trans.* for the year 1755, and *Cronstedt's Mineralogy*, §. 108.

(d) Zinc when broken appears of many flat, shining plates, or facets, which are larger when slowly than when hastily cooled.

When

The specific gravity of zinc is nearly the same as that of regulus of antimony; that is to say, it loses in water about a seventh part of its weight. (e)

This semi-metal is not easily calcined or covered with rust by the action of the air and of water: in this respect it resembles tin. It is less fusible than tin and lead, as it does not melt till it is almost red-hot. When it only suffers the degree of heat necessary for its fusion, its surface is calcined and reduced to a grey calx, easily reducible, like those of tin and other fusible metallic substances. But when it is exposed to heat approaching to a white-heat, it flames; and during this inflammation it exhibits a very beautiful and striking appearance. The flame of zinc is infinitely more lively, more luminous, and more brilliant, than the flame of any other inflammable matter. It is of a dazzling white, and is so vivid as to be insupportable to the sight. This flame cannot be attributed to any sulphur which might be supposed to remain united with the zinc, for we shall see that this semi-metal cannot be united with sulphur; but merely to phlogiston, which in zinc is very combustible. This ardent deflagration is a most sensible proof of the presence of this principle in metallic substances.

The deflagration of zinc is so violent that the earth of this semi-metal although naturally very fixed, like that of almost all metallic substances, is raised in form of white smoke, which is condensed, and floats in the air like light flocks. These are called *flowers of zinc*, and *philosophical wool*. See *FLOWERS of ZINC*.

Zinc being the most combustible of all metals, detonates more violently than any other metal with nitre. From the whiteness and brilliancy of the flame produced by this detonation, it has been employed with very good effect as an ingredient in compositions for fireworks.

All acids are capable of dissolving zinc. Six parts of good vitriolic acid diluted with an equal weight of water can dissolve entirely, by help of gentle heat, one part of zinc. The neutral salt resulting from this solution is crystallizable, and is called *white vitriol*, or *vitriol of zinc*. See a description of the method in which this vitriol is made at Goslar, at the article. *SMELTING of ORES*.

Zinc has a strong affinity with vitriolic acid. It appears to have a stronger than any other metallic substance: for by means of this semi-metal, the vitriols of copper and of iron may be decomposed. It separates these metals from the vitriolic acid, to which it unites and forms a white vitriol. But what is remarkable, is, that notwithstanding this great affinity of zinc with vitriolic acid, the vitriol of zinc is decomposed, and its acid separated by less heat than the martial vitriol, as Junker affirms in the first volume of his *Compendius Chymie*. If this experiment succeeds, as probably it does, we must refer the cause of it to the particular states of the inflammable principle in zinc and in iron. All the properties of these two metallic substances shew that they abound in phlogiston, and therefore vitriolic acid unites with them preferably to any other. But, at the same time, this phlogiston is in these metals much

When heated, it is very brittle. Like tin, it makes a crackling noise when it is bent.

(\*) According to Mulchenbroek's table

of specific gravities, Indian zinc is to water as 7.2401 to 1: and zinc of Goslar is as 7.215 to 1.

unfolded.

unfolded and weakly combined, which is undoubtedly the cause, that the neutral salts which they form with the vitriolic acid may be decomposed by the action of fire. For, the phlogiston of these metals adhering but slightly to their earth, may be more easily combined with the vitriolic acid, and by converting this acid into volatile vitriolic, or sulphureous acid, may still more facilitate its separation.

But as the inflammable principle of zinc is more abundant, and more slightly engaged than that of iron, zinc ought to unite with vitriolic acid preferably to iron, and the vitriol of zinc ought to be decomposed by fire more easily than the vitriol of iron.

When white vitriol is distilled by violent heat, nearly the same phenomena happen as when martial vitriol is distilled. Towards the end of the distillation of white vitriol, a vitriolic acid arises, dephlegmated, tho' very sulphureous. This acid added to common concentrated vitriolic acid produces as much heat as water would have done, if added to the same concentrated acid.

Zinc may also be dissolved in the nitrous and marine acids. But this latter acid does not touch a black matter which separates from the semi-metal during its solution. M. Hellot who has examined the phenomena of this solution as well as those of the solutions of this semi-metal in the vitriolic and nitrous acids, has ascertained that this black matter is not mercury, and that it cannot even be reduced into a metallic substance. (f)

Zinc may be alloyed or mixed with all metallic substances excepting *bismuth* (g). If these two metals be melted together, they will be found separately at the bottom of the crucible, the zinc being the lighter lying above the bismuth. The alloy of zinc with iron is effected difficultly; but that with copper succeeds well, and is much used, on account of a singular property which zinc has of uniting with copper in a considerable proportion; as, for instance, one part of zinc to four or three parts of copper, without much diminution of the ductility of the copper. Zinc added to copper renders this metal less subject to rust, and gives to it a yellow color resembling that of gold. This copper so alloyed with zinc is called *brass* or *latten*. See BRASS.

The color of brass approaching to that of gold, has induced chemists to search for the means of communicating to copper the true color of gold. And they have actually succeeded in the compositions or alloys called *tombacs*, *finitior*, *Pinchbeck*, and *Prince's metal*. Beccher had said, that equal parts of copper and zinc mixed together gave a color to the touch-stone like that of the gold from the Rhine. Stahl remarks that the proportion of zinc mentioned by Beccher is too great, but does not determine what this proportion ought to be. Since that time, the due proportion has been investigated, and several fine imitations of gold have been found. The English were the first who succeeded, and they called their invention *Prince's metal*, or *Prince Rupert's metal*.

More perfect imitations of gold have been lately made by Lacroix and Leblanc; each of whom produced a metallic mixture, one of which excelled in

(f) Neuman says, that this black matter was separated during the solution of this semi-metal in vitriolic and in marine acids, and that two or three days afterwards it was re-dissolved.

(g) It cannot be alloyed with the semi-metal called nickel.

ductility, and the other in color. But these artists have not revealed their processes. M. Geoffroy has made with this view many experiments, the detail of which may be seen in the Memoirs of the Academy for the year 1725. It appears from these experiments, that the remark made by Stahl, that an equal quantity of zinc is too much, was very just, with regard to the ductility of the alloy, but that equal quantities produced the finest color. We may nevertheless observe, that as copper requires a strong heat to keep it fused, and as zinc is very volatile, these two substances cannot be mixed without loss, both of the copper, some of which is calcined, and of the zinc, a part of which is burnt and dissipated in fumes. Hence it follows, that after the mixture is made, the proportion betwixt the two metals is not certain. After some experiments which I have seen, I can scarcely be persuaded that a fine-colored mixture can be obtained, and particularly of a deep enough yellow, if as much zinc as copper actually remained. (b)

We must also observe, that in order to have a fine-colored and ductile metallic mixture of this kind, it is necessary, according to Mr. Cramer, to use the purest zinc. The same author shews the means of purifying it, and of ascertaining its purity. This method is founded on the remarkable property which zinc has of being incapable of uniting with sulphur (i). Therefore, to purify this semi-metal from the alloy of other metals, it is necessary to throw upon it, when melted in a large crucible, suet and sulphur alternately, and the latter in larger quantities than the former. If the zinc is pure, the sulphur burns freely on its surface; but if it is alloyed, the sulphur combines with the other metals, and forms with them a kind of scoria which must be taken off. This alternate projection of suet and sulphur upon zinc is continued till the sulphur be burnt on the surface of the melted zinc, without forming any scoria; the zinc thus purified, may be successfully employed for making of brass or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr. Gellert's table, in the following order: Copper, iron, silver, gold, tin, and lead. This last is said to be only partly miscible with zinc. Sulphur might be so placed in this table, as to shew its incapacity of uniting with zinc.

The chief use of zinc is as an ingredient in the composition of brass. M. Malouin, who, in his Memoirs upon Zinc, has mentioned several properties of this semi-metal which he finds analogous to those of tin, relates in these Memoirs some experiments which he made with success, in order to substitute zinc for tin, in the operation upon iron plates, &c. called *tinning*. As all the properties

(b) One part of zinc is said to be capable of destroying the ductility of a hundred parts of gold. An alloy of equal parts of zinc and gold is very hard, white, capable of receiving a fine polish, and not subject to rust or tarnish: hence it is proposed by Mr. Malouin as a good material for making specula of telescopes. Zinc gives hardness to tin, and is therefore added in some compositions for making pewter.

(i) Mr. Cramer says that zinc does not easily unite with sulphur, but that if it remains long in a moderate fire, and be covered over with sulphur at several times, and continually stirred with a poker, it will be at last changed into a very brittle, dark-colored substance. I suspect that the iron of the poker contributed to this union of zinc with sulphur, for I have never been able to unite sulphur with pure zinc, when I stirred them with a tobacco-pipe.

of this semi-metal are not yet discovered, it may perhaps be hereafter found applicable to other uses. (k)

(k) Some authors, as Wallerius and Stedt, say, that filings of zinc are attracted by magnets. I have not been able to find this property.

Zinc unites more strongly with any other metal, and even some earths. Pott says, that it precipitates the earth from a solution of alum; and that zinc cannot be precipitated from aqua fortis by brass-eyes. He also says, that it may be precipitated by volatile alkali, but that this precipitate is quickly re-dissolved.

The same author says, that zinc, by being converted into flowers, acquires an additional weight, equal to  $\frac{1}{10}$ th part of the semi-metal employed.

Mr. Malouin relates, that zinc being melted six times, and the fusion continued 15 hours each time, it became more and more hard, brittle, unfusible, and uncalcinable. He says, that its color became grey after the second fusion, brown after the third, black after the fourth, blue like a slate after the fifth, and a clear violet-color after the sixth.

Concerning the ores and assay of ores of zinc, see ORES of ZINC; and concerning the methods of extracting large quantities of this semi-metal from its ores, see SMELTING of ORES, and PLATE II. Fig. 15, and 22, with the explanations.

F I N I S.





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## CORRECTIONS AND ADDITIONS.

**PAGE 2.** *Notes, column second, line fourth.* Instead of, "them with a certain quantity of water," read, "concentrated acids with a certain quantity of water or of ice."

*Page 3. Notes, column first, line 14.* Instead of, "they," read, "moist, if not all of them, when much concentrated."

*Ibid. col. 2, line 31.* Instead of, "of solid acid in each neutral salt," read, "that each neutral salt retains of the acid liquor employed in its preparation."

*Page 4. Notes, col. 1, line 4.* Instead of "shall," read, "should."

*Ibid. line 8.* Instead of, "Hence we may perceive, &c." *to the end of the sentence,* read, "But as a less quantity of acid was said to have been actually employed, Mr. Homberg's alkali must have contained a less quantity of fixable air than we have supposed. But as we do not know the precise quantity of that air, nor the degree of dryness of his alkaline salt, we cannot from his experiments ascertain the quantity of pure, dry, caustic alkali, contained in any of the neutral salts produced; nor can we determine how much of the acid liquor employed was retained in those neutral salts after they had crystallized."

*Page 9. Notes, col. 2. line 8.* Instead of, "but not volatile alkali," read, "but it does not render volatile alkali soluble in spirit of wine."

*Page 33. Note (b), line 1.* Instead of, "term," read, "name."

*Ibid. Notes, col. 2, line 1.* Instead of, "this," read, "his."

*Page 34. Notes, col. 1, line penult.* Instead of, "combined," read, "uncombined."

*Page 35. Notes, col. 2.* After the 28th line add, "Dr. Macbride shews, that the air extricated from fermenting and putrefying substances is capable of combining with caustic alkalis, and with quicklime, and of rendering these mild. This air is therefore probably of the same kind as the air usually combined with alkaline substances."

*Page 37. Notes, col. 1.* After the second line, add, "Concerning the fixable air contained in *mineral waters*, and its power of *dissolving calcareous earth*, and *iron* contained in these waters, *see the article WATERS (MINERAL)*, and *a Note subjoined.*"

*Page 40.* Add the following *note*, referring to the article ALKALESCENT. "This word signifies the tendency of bodies to become alkaline; and cannot be properly applied to signify a slight degree of alkaline quality."

*Page 49. Notes, col. 1, line 11.* Instead of, "in ordinary distillations," read, "in the ordinary method of distilling wood, together probably with some of its more fixed parts."

Page 55. Notes, col. 2, line 1. Instead of "this salt to," read, "the mineral to the."

Page 62. Notes, col. 2, line 2. Instead of "by their different densities," read, "by fusion, according to their different densities, that is, the heavier metal sinking below the lighter."

*Ibid.* line 25. Instead of "by their different densities," read, "by means of their different densities."

Page 73. Notes, col. 1, line 9. Instead of "earth," read, "substance."

*Ibid.* col. 2, line 10. Instead of "The same," read, "An equal."

Page 75. Notes, col. 2, line 2. Dele "Hence."

*Ibid.* At the end of the note (i) add, "But as mercury has been found to rise to a less height in barometrical tubes of iron than in those of glass, have we not reason to believe that these metals possess a power of repelling each other? See the *Hist. de l'Acad. Roy. de Sciences*, 1706."

Page 91, line 15. Instead of "flux," read, "resolvent."

Page 99. Notes, col. 2, last line. Instead of "coco," read, "coco."

Page 117. Instead of the paragraph beginning thus, "Some authors commend, &c." read the following paragraph, as it is altered by the Author of the Dictionary.

"Several Chemists, amongst whom is Mr. Pott, have believed that the solution of bismuth, which when well saturated, may be precipitated by water, could not be precipitated by means of the marine acid, as those of lead and silver may, and consequently that a corneous bismuth could not be formed. But Mr. Rouelle, in his Memoir upon Salts, [*see Mem. de l'Acad. des Sc.* 1754.] says, that after having precipitated from a well saturated solution all the bismuth that he could by means of water, he obtained a new precipitate by adding to the remaining liquor an equal quantity of saturated solution of sea-salt, and by gradually mixing with these a quantity of common water equal to four times the quantity of the two solutions. This second precipitate is considered by Mr. Rouelle as a corneous bismuth. "If this be the case, bismuth resembles lead in many of its properties, as Mr. Geoffroy the Younger has shewn in the Memoirs of the Academy of Sciences. Accordingly, some chemists have called bismuth, the lead of the semi-metals."

Page 124. Instead of the paragraph beginning thus, "A chemist of Berlin having, &c." read the following paragraph, as it is altered by the Author of the Dictionary.

"Stahl relates in his *Three Hundred Experiments*, &c. No. 231, the manner in which this blue matter was discovered. He says, that a manufacturer of colors, called *Diesbach*, who usually prepared a lake of cochineal by mixing a decoction of this substance with alum and green vitriol, and by precipitating the mixture with a fixed alkali, being one day in want of fixed alkali, for this purpose borrowed from *Dippel*, in whose laboratory he worked, some salt of tartar, from which that chemist had several times distilled the animal oil called *oil of Dippel*, and observed that the lake precipitated by means of this alkali, instead of being red, was of a fine blue color. *Dippel*, to whom *Diesbach* related this appearance, perceived that it must have been caused by his alkali, and attempted to produce the same effects by giving the same

" same quality to fixed alkali by an easier process. His attempts succeeded,  
 " and from that time Prussian blue has been prepared."

Page 131. Notes, col. 2. line penult. Instead of " in," read, " of."

Page 138. line 20. Instead of " cacao, butter," read, " cacao-butter."

Ib. line 34. Dele " made."

Page 142, line 36. Instead of " that," read, " why."

Page 151, line 37. Instead of " ferruginous and sulphureous," read, " fer-  
 " ruginous, sulphureous."

Page 181. Notes, col. 2. line 4. Instead of, " after a red heat has been gra-  
 " dually applied," read, " after heat has been gradually applied till the cru-  
 " cibles become red."

Page 216. Notes, col. 1, line 12. dele " also."

Page 226. Notes, col. 1. line 22. Instead of the sentence beginning with, " If  
 " we mean by element, &c." read the following sentence: " But if we should  
 " call every substance an *element* which we cannot analyse, then certainly many  
 " other substances besides the above-mentioned four might be enumerated  
 " as elements."

Page 253. Add the following note, referring to the *sixth* line.

" The method employed by Mr. Beaumé for obtaining a marine ether,  
 " namely, by uniting the vapors of spirit of wine with those of marine acid,  
 " has been successfully attempted by Mr. Woulfe. This ingenious chemist  
 " condensed the united vapors of the spirit of wine, and of the marine acid, by  
 " making them pass from the receiver through a tube into spirit of wine con-  
 " tained in a bottle, and by making those which were not thus condensed pass  
 " through another tube into more spirit of wine contained in another bottle.  
 " By distilling and cohobating with slaked lime the liquors in the receiver, and  
 " in the two above-mentioned bottles, he obtained a very subtle and pene-  
 " trating ether. See a description of the apparatus employed by Mr. Woulfe, and  
 " many curious particulars concerning distillation, in the *Philosophical Trans-*  
 " *actions*, Vol. LVII."

Page 254. Add the following note, referring to the *seventeenth* line.

" Mr. Woulfe describes an apparatus by which nitrous ether may be expediti-  
 " ously obtained by distillation; with the heat only occasioned by mixing together  
 " the nitrous acid and the spirit of wine. This distillation is performed in a  
 " matrafs with a high neck, to which is fitted a head, with a spout, commu-  
 " nicating with the receiver by means of a long tube. Those vapors which are  
 " not condensed in this receiver are conveyed from thence through a bent  
 " tube into spirit of wine contained in a bottle; and if any vapors pass uncon-  
 " densed through this spirit of wine, they are conveyed, through another bent  
 " tube, into more spirit of wine contained in another bottle. The liquor  
 " collected in the receiver, being slowly rectified with slaked lime, furnishes  
 " very fine ether. The spirit of wine in which the vapors were condensed  
 " contains so much ether, that this fluid may be separated from the spirit by  
 " adding water. This spirit of wine is, by the operation, converted into very  
 " good dulcified spirit of nitre. See the *Phil. Transf.* Vol. LVII.

Page 276. Notes, col. 1. line 39. Instead of, " when the flame has a con-  
 " siderable diameter, as of a foot or eighteen inches, and," read, " when a  
 " vapor

" vapor of a considerable diameter, as of a foot or eighteen inches, is kindled, and the combustion"

Page 278. Notes, col. 2. line 4. Instead of the sentence beginning, " They are also convertible, &c." read, \* By means of fixed alkali they may be fused and vitrified : and when the quantity of fixed alkali is much greater than that of the flints, the melted mass deliquesces by exposure to a moist air, and becomes the liquor called *liquor of flints*, from which an earth may be precipitated, by adding an acid. This earth, which must have been originally the earth of the flints or sand employed, is now rendered soluble in acids, and, as Mr. Pott says, is *calcareous*, or, as Mr. Beaumé affirms, is *argillaceous*."

Page 294. Dele Note (m).

Page 301. Notes, col. 1. line 5. Instead of, " contain nitre, sal ammoniac, or common salt, alum, or some vitriolic salt," read, " contain nitre, alum, or other vitriolic salt, and sometimes sal ammoniac or common salt."

The same page, Notes, col. 1. line penult. Instead of the three successive sentences, the first of which begins thus, " Accordingly, in all the receipts, &c." and the last of which sentences ends thus, " quickly plunges it in water," read the following : " This effect may be produced either by applying to the metal an aqua fortis, by which any remaining mercury, or alloy of copper, or of other metals, that might discolor the gold, might be dissolved ; or by an aqua regia, which also would cleanse its surface, but, at the same time, might dissolve the gold itself, if applied a time sufficiently long. Now, in all the receipts which I have seen for this saline compound, I have always observed nitre and alum, or some vitriol, together with other matters. From these ingredients, by exposure to heat, an aqua fortis is evidently formed, the acid of the alum or other vitriol disengaging the acid of the nitre. In several of these receipts I have seen added to the above-mentioned salts some sal ammoniac or common salt. By this addition, an aqua regia is formed, which may, as we have said, also cleanse the surface of the gold ; but, as it may dissolve part of the gold itself, even in the very short time during which it is applied, the former compound, from which the nitrous acid only is disengaged, seems to be preferable, and is now generally employed."

Page 336. Notes, col. 2. line 13. Instead of, " that it deliquesces," read, " that glass-gall deliquesces."

Page 310. Notes, col. 1, line 5. Instead of, " but those persons," read, " but this action of Moses is evidently related, and ought to be considered, as miraculous, and therefore not explicable by natural means. As to those persons"

Ib. col. 2, line 1. Instead of, " will," read, " they will."

Page 312, line 20. Instead of, " and so fixed," read, " and will become so fixed."

Page 314. Notes, col. 2, line 3. After " fused," add a comma.

Page 478. Notes, col. 1, line 6th from the bottom. Instead of " coeval," read, " coeval, or nearly coeval."

Page 316, line 38. Instead of, " behind," read, backwards."

Page 324, line 15. Add the following Note. " This proposal is of a much older date than the Memoir of M. de la Condamine."

- Page 361, line 20. Instead of, "citing," read, "exciting."
- Page 409, line 23. Instead of, "method of friction," read, "method by friction."
- Page 425, line 15. Instead of, "By water," read, "With water."
- Page 429. Notes, col. 2, line last: Instead of, "copper, iron," read, "iron, copper."
- Page 476. Notes, col. 1, line 4. Dele "up."
- Page 479. Notes, col. 1, line 3. After "in a fluid state," add, "and dissolved in water;"
- Page 504. Notes, col. 2, line 9th from the bottom. Dele "also."
- Page 552. Notes, col. 1, line 1. Instead of, "The petuntse is improperly ranked amongst the class of earths called vitrifiable, because, &c." read, "The petuntse is ranked amongst the earths called vitrifiable, improperly, as I think, because, &c."
- Same page, col. 2; line 3d from the bottom. Instead of, "analised," read, "analysed."
- Page 555. Notes, col. 1, line 14. Instead of, "all of which are fusible," read, "which are singly or jointly fusible."
- Page 591. Notes, col. 1, line 10. Instead of, "inexhausted," read, "exhausted."
- Same page, Notes, col. 1, line 24. Add, "But no inferences ought to be drawn from experiments, which appear, from the author's own account, to have been inaccurate, and not repeated."
- Page 607. Notes, col. 1, line 4. Instead of, "or," read, "as."
- Page 608. Notes, col. 1, line 9. Instead of, "unites so rapidly as to occasion," read, "unites rapidly, and occasions."
- Page 742. Notes, col. 1, line 4. Instead of, "volatile, vitriolic," read, "volatile vitriolic."
- Page 815. Notes, col. 1, line 11. Instead of, "crown-glass," read, "flint-glass;" and line 12, instead of, "flint-glass," read, "crown-glass."



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E X P L A N A T I O N  
O F T H E  
P L A T E S.

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P L A T E I.

- FIG. 1. **A** RETORT.  
A, Its belly or bowl.  
B, Its neck.
- FIG. 2. Retorts of this form are called *English Retorts*.
- FIG. 3. A GLASS ALEMBIC.  
A, The cucurbit.  
B, The head.  
C, The gutter within the head.  
D, The beak.
- FIG. 4. A LONG-NECKED GLASS ALEMBIC.  
A, The body of the matrafs.  
B, The neck of the matrafs.  
C, The head of the alembic.
- FIG. 5. A GLASS ALEMBIC *consisting of one Piece*.  
A, The cucurbit.  
B, The head.  
C, The aperture in the head.  
D, Its stopple.  
E, The mouth of the cucurbit.
- FIG. 6. A PELICAN.  
A, The cucurbit.  
B, The head.  
C, The aperture in the head with its stopple.  
D, The two curved spouts.
- FIG. 7. A ROW of ALUDELS,

## FIG 8. A COPPER ALEMBIC.

- A, The body or cucurbit.
- B, The neck.
- C, The head.
- D, The beak, nose, or spout.
- E, The refrigeratory or cooler.
- F, Its cock.
- G, The receiver.

## FIG. 9. A MUFFLE.

FIG. 10. *A perpendicular section of a CUPPEL or TEST.* The curve line represents the bottom of the cavity that contains the metal. The plan or any horizontal section of a cuppel is a circle.

FIG. 11. AN INGOT-MOULD, into the cavities of which melted metals are poured.

FIG. 12. AN APPARATUS for DISTILLING, by which the vapors that usually escape in the ordinary method of distillation, are condensed by passing into water or some other fluid. This apparatus was invented and described by Mr. Peter Woulfe. See the *Phil. Transf.* Vol. LVII.

A, a retort. Instead of this retort, in the distillation of some substances, may be substituted an iron pot with a stone-ware head, the neck of which is to be inserted into the receiver, as in the present Figure.

B, a receiver, with a neck, into which the neck of the retort is to be inserted; and a spout at its bottom, through which the distilled liquor passes into the bottle C; and an opening in the side at D, into which one end of a tube bent at right angles is inserted. The other end of this tube passes into a vessel H, open at both ends, the lower opening of which is closed with a glass stopple. Through the upper mouth of the vessel H, one end of another tube I, bent twice at right angles, passes, while the other end of this tube is inserted into a bottle F, and immersed in the water or other fluid contained in that bottle. The crooked tubes are fitted into the mouth of the vessel H by means of a cork, in which are two semicircular notches, through which the tubes pass, and by lute.

The tube which passes into the bottle F is fitted into the mouth of this bottle by means of a cork, in which is a semi-circular notch. This mouth of the bottle F is not closed with lute.

The vapor that is raised from the substance exposed to heat in the retort passes into the receiver B, where part of it is condensed, and flows into the bottle C, while the rest of it passes through the tube at D, into the vessel H. From this vessel, the vapor that still remains uncondensed passes through the crooked tube I, into the water contained in the bottle F, by which it is all condensed excepting some elastic air, which is extricated in almost all distillations. This elastic air rises through the water, and escapes at the semi-circular notch of the cork in the mouth of the vessel, which is therefore not accurately closed by lute.

In most distillations a quantity of air is absorbed at different times during the process: and in this case the external air will press on the liquor in the bottle F, and force it through the tube I into the vessel H, from which it may be taken by opening the stopple L.



The use of the vessel H is to receive the liquor that may be thus raised from the bottle F, and to prevent it from passing into the receiver B, and from thence into the bottle C, where it might spoil the distilled liquor.

Mr. Woulfe, in the above-mentioned Philosophical Transaction, relates several experiments made with this apparatus, from which the utility of this method of condensing vapors by making them pass into water, or some other fluid suited to the nature of the liquor distilled, appears.

Thus, by distilling twelve pounds of sal ammoniac with quicklime and two gallons of water, he obtained eight pounds and a quarter of volatile alkaline spirit sufficiently strong to make eau de luce, which were collected in the bottle joined to the receiver; and upon adding two other gallons of water, he obtained seven pounds of weak volatile alkaline spirit. The water contained in the bottle F, which was six quarts, received an increase of  $2\frac{1}{2}$  lb. in weight from the vapor condensed in it; and from experiments made to compare the strength of the alkali thus condensed by the water with that of the strongest alkaline liquor first obtained, and which we have said was fit for making eau de luce, it was found, that the strength of the former was to that of the latter as 140 to 76: hence the quantity saved by this apparatus was nearly equal to five pounds of volatile alkali sufficiently strong for making eau de luce. Mr. Woulfe observed a singular difference betwixt the alkaline liquor collected in the bottle joined to the receiver, and that which was condensed in the water in the bottle F, namely, that a considerable heat was excited by mixing the latter alkaline spirit, but not the former, with vitriolic acid.

Another experiment is related, of the distillation of twelve pounds average of common salt with an equal quantity of oil of vitriol diluted with 7 lb. of water. In this operation 9 lb. 5  $\frac{1}{2}$  oz. of spirit of salt were collected in the bottle C, and 6 lb. 12  $\frac{1}{2}$  oz. of the same spirit were condensed in six quarts of water in the bottle F. The residuum weighed 18 lb. 6 oz. Hence in this operation there was a loss of eight ounces, or  $\frac{1}{10}$ th part of the whole, most of which probably was elastic air. The strength of the acid condensed in the water was found, by experiment, to be to the strength of the acid collected in the bottle C, as 200 is to 109. These vapors, condensed in water, were found to be more concentrated when the distillation was conducted slowly than when it was hastened. It appeared also, that the most concentrated portion of the acid of sea-salt is the most volatile, and that its strength was to that of vitriolic acid (the specific gravity of which was to that of water as 24 to 13), as 44  $\frac{1}{2}$  to 31. Experiments also shewed, that this vapor of spirit of salt condensed in water contained no vitriolic acid, although the spirit collected in the bottle C did contain some of that acid.

The same ingenious chemist formed a *marine ether* by applying the vapor of rectified spirit of wine to this very concentrated vapor of marine acid, and by condensing the united vapors in spirit of wine. This he effected by a well contrived apparatus. The necks of two retorts, one of which contained the spirit of wine, and the other the sea-salt and vitriolic acid, from which the marine acid was to be distilled, opened into one receiver, where the vapors met: from this receiver the vapors passed through a tube into spirit of wine contained in a bottle; and those which were not there condensed passed through another tube into spirit of wine contained in a second bottle. By a further distillation

distillation and cohobation, with slaked lime, of the several liquors collected in the receiver and in the spirit of wine in which the vapors were condensed, a very subtle penetrating ether was produced. Mr. Beaumé had tried to procure a marine ether by uniting the vapors of the marine acid, and of spirit of wine; but he failed, because he did not use an effectual method of condensing the vapors.

Mr. Woulfe did not find that much advantage was gained by this method of condensing vapors in water, in the distillation of the nitrous acid from nitre mixed with vitriolic acid, excepting that thus the noxious fumes are prevented from hurting the operators.

He thinks his proposed method of condensation may be applicable to the distillation of vitriolic acid, the sulphureous fumes of which are difficultly condensable; to the rectification of phosphorus, the vapor of both which substances ought to be condensed by means of water; to the rectification or distillation of vitriolic ether, the vapors of which ought to be condensed in spirit of wine; and, lastly, to many other distillations.

## P L A T E II.

FIG 1. *An ESSAY or CUPELLING FURNACE.* This figure and the following description of this furnace are copied from *Cramer's Art of Assaying.* See Dr. Mortimer's *English Edition*, p. 75.

"The assaying furnace is made in the following manner:—1. Make with iron plates a hollow quadrangular prism, eleven inches broad and nine inches high (*a a, b b*), ending at top in a hollow quadrangular pyramid (*b b, c c*), seven inches high, terminating in an aperture at top seven inches square. This prism must be closed at bottom with another iron plate, which serves as a basis or bottom to it (*a a*). 2. Near the bottom make a door (*e*) three inches high, and five inches broad, that leads to the ash-hole. 3. Above this door, and at the height of six inches from the basis, make another door (*f*), of the figure of a segment of a circle, four inches broad at its basis, and three inches and a half high in the middle. 4. Then fasten three iron plates on the forepart of this furnace; let the first of them (*g g*), eleven inches long and half an inch high, be fastened, so that its lower edge shall rest against the bottom of the furnace, with three or four rivets, and in such a manner, that there may be between the upper edge of the said plate and the side of the furnace a groove so wide, as that the sliders of the lower door (*k k*) may be put into it, and freely move backwards and forwards therein: these must be made of a thicker iron-plate. The second iron-plate (*b b*), eleven inches long, three inches high, and perfectly parallel to the foregoing plate, must be fastened in the space between the two doors, in such manner, that both the upper and the lower edge of it may form

form a hollow groove with the side of the furnace. One of these grooves, which is turned downwards, serves to receive the upper edges of the sliders that shut the lower door (No. 2.) The other, that turns upwards, is to receive the inferior edges of the sliders of the small door above (No. 3). The third plate (*i i*), which is like the first, must be rivetted close above the upper door, in such manner, that it may form a groove turning downwards, and contiguous to the upper edge of the upper door (No. 3.). 5. In order to shut both doors (No. 2. and 3.), you must adapt to each of them two sliders made of iron-plates, that may move within the above-mentioned grooves (*k k, l l*); but the two sliders belonging to the upper door (No. 3.) must have each a hole near the top; that is, one a small hole one fifth part of an inch broad, and one inch and a half long (*m*); and the other a semi-circular aperture, one inch high and two inches broad (*n*). Let, besides, each slider have a handle, that they may be laid hold of when they are to be moved. 6. Moreover, let five round holes, one inch broad, be bored in the furnace, two of which must be made in the fore-part of the furnace (*o o*), two others in the back-part, all at the height of five inches from the bottom, but three inches and a half distant from each side of the furnace; and, finally, a fifth hole (*p*), at the height of one inch above the upper edge of the upper door (*f*). 7. In short, let the inside of the furnace be armed with iron-hooks, jetting out half an inch, and about three inches distant from each other, to fasten the lute with which the furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular pyramid (*q*), three inches high, be adapted to the upper aperture (*d*) of the furnace, at the basis seven inches broad, ending upwards in a hollow tube (*r*), three inches in diameter, two inches high, almost cylindrical, though somewhat convergent at top. This prominent tube serves to support a funnel or flue, which is almost cylindrical, hollow, made of iron-plates, and two foot high, and which, when a very strong fire is required, is put perpendicularly upon the shorter tube, in such manner, that it enters close into it, one inch and a half, ~~or~~ two inches deep, and may again be taken off at pleasure, when there is no need of so strong a fire. But this pyramidal cover (*q*) must besides have two handles (*s s*) adapted to it, that it may be laid hold of, and thus be taken away or put on again: and that this, being put on the aperture (*d*) of the furnace, may not be easily thrown down, let an iron plate be rivetted to the right and left upper edge of the furnace (*c c*), and be turned down towards the inside, so as to make a furrow open before and behind, into which the lateral edges of the cover may enter and be fastened, and at pleasure be moved backwards and forwards, whenever it must be put on, or moved. 9. Let a square ledge, made of a thick iron-plate, be fastened at top of the upper edge of the lower door (*e*); this is designed to support the grate and the lute: but it must be made of two pieces, that it may be easily introduced into the cavity of the furnace. Thus you will have an assay-oven, which must afterwards be covered over on the inside with lute. This you are to do as follows:

“That the fire may be better confined, and that the iron may not be destroyed by growing red-hot, the whole inside of the furnace must be covered over with lute, one finger or one finger and a half thick. The lute fit for this is made of a mass of clay mixed with sand, and moistened with three or four times as much.

much of ox-blood diluted with water \*. But before you cover the inside of your furnace with this lute, you must first put within the furnace small iron bars, equal in length to the diameter of the oven, quadrangular, prismatical, half an inch thick, having their extremities supported by a square iron ledge, and three-fourths of an inch distant from each other; and you must fasten them so, that their flat sides may be oblique with regard to the transverse section of the furnace, and that the two opposite angles may look one upwards and the other downwards; the bars must not be laid flat, but edge-ways, by which situation you hinder the ashes of the fuel of the fire from being detained too long between the interstices of the said iron-bars, and from making an obstruction that would oppose the free draught of the air. The furnace being then covered over with lute, and dried up by a gentle heat, is at last fit for docimastical operations, and especially for such as must be performed in the assay-oven.

If then an operation is to be made in the furnace hitherto described, you must let through the four lower holes above described, of the furnace (*o o*) placed before and behind, and directly opposite to each other, two iron-bars one inch thick, and long enough that their extremities on every side may jut out of the holes a small matter. These serve to support the muffle and its bottom (*See PLATE I. FIG. 9.*). You then introduce the muffle through the upper aperture of the furnace (*d*), and place it upon the above-described iron-bars, in such manner, that the open fore-side of it be contiguous to the inward border of the upper door (*f*). The fuel of the fire is introduced through the top of the furnace (*d*); the cover of which, on this account, must be moveable and not very heavy (*g*). The best fuel for the fire is charcoal made of the hardest wood, especially of beech, broken into small pieces of the bigness of an inch, where-with the muffle must be covered over some inches high. We then reject larger bits of coals, because they cannot fall through the narrow interstices, between the sides of the muffle and those of the furnace, and cannot of course sufficiently surround the circumference of the muffle. Whence it happens, that there are on every side places void of fuel, and the fire is either not strong

\* The best lute, and easiest to be had at London, is a sort of clay called Windfor loam, which must be mixt pretty stiff, and pressed into the inside of the furnace, first wetted with water; and when the clay begins to dry, it must be beat down close to the sides with a wooden mallet; then the unevenness and cracks filled up with fresh clay somewhat moister, so as to be made smooth and even with a trowel, and then left to dry gently; and if any cracks happen, they must again be filled up. *Note of Dr. Mortimer.*

Stourbridge clay, tobacco-pipe clay, or any other pure clay that is not fusible by fire, may be used for this purpose. But as fresh clay shrinks and cracks very much in drying, it ought to be mixed with an equal quantity or more of coarse white sand, or of burnt

clay grossly powdered. Thus one part of Stourbridge clay, one part of coarse white sand, and one part of Stourbridge bricks grossly powdered, being well mixed together, make a good lute for lining the inner surfaces of furnaces. To prevent the iron plates of the furnaces more effectually from calcination, their inner surfaces ought to be covered with a coating of charcoal-powder formed into a mass or paste, with as much fresh clay and water as are sufficient for that purpose; and when this coating is dry, the above-mentioned lute may be applied. During the drying the lute ought to be daily beat with a mallet, that the spaces left by the shrinking of the clay may be closed, and the lute be rendered more compact.

enough

enough or unequal. But if, on the contrary, you use coals too small, then a great part fall immediately through the interstices of the grate into the ash-hole; and the tenderest particles of them turn too soon into *ashes*, and by increasing the heap of ashes, obstruct the free draught of the air, which is here greatly requisite.

“ A perfect management of the fire is most commonly necessary in the performing of operations in this furnace; therefore the reader must give attention to what follows: If the door of the ash-hole (*e*) is quite open; and the sliders of the upper door (*f*) drawn towards each other, so as touch one another in the middle of the door; and if, besides, the cover (*q*), and the funnel adapted to its tube (*r*), is upon the top (*q*) of the furnace, the fire will be then in the highest degree possible; though, in the mean time, it is hardly ever necessary to put the funnel on, except in a very cold season: but if, after having disposed the furnace in the manner just described, you put red burning coals into the open upper door (*f*) of it, the fire is still more increased thereby: however, this artifice is never, or very seldom, necessary. When you shut the upper door with only that slider that has a narrow oblong hole in it (*m*), then the heat becomes a little less; but it diminishes still more when you shut the door with the other slider that has in it the semi-circular hole (*n*), which is larger than that of the first slider: nay, the heat again is less when you take away the funnel put at top of the cover: finally, the door of the ash-hole being either in part or totally shut, the heat is still diminished, because the draught of the air, so necessary to excite the fire, is thereby hindered: but if, besides all these, you likewise open the upper door quite, then the cold air, rushing into the muffle, cools the bodies put under it, that are to be changed, to a degree never required in any operation, and such as will entirely hinder the boiling of lead. If, during the operation, the fire begins to decay, or to grow unequal, it is a sign that there are places void of coals between the sides of the furnace and those of the muffle; therefore, in this case, you must stir your coals on every side with an iron-rod, which is to be introduced through the upper hole (*p*) of the furnace, that they may fall together, and thus act in a proper manner and equally.

“ However, you are to observe concerning the regimen of the fire just described, that though the *apparatus* is made with all the exactness mentioned, nevertheless the effect does not always answer it. The cause of which difference has most commonly its origin in the various dispositions of the air; for as every fire is more excited by coals in proportion as the air, more condensed, and more quickly agitated, strikes them more violently (which the effect of bellows plainly shews); it thence appears, that in warm and wet weathers, when the atmosphere is light, the fire must be less efficacious in furnaces; that likewise, when several furnaces, situated near each other, are burning at the same time, the fire is in part suffocated; because the ambient air is thereby rendered more rare and lighter. The same effect is produced by the sun, especially in summer-time, when it shines upon the place where the furnace is situated. The atmosphere, on the contrary, being heavier in cold dry weather, excites a very great fire.

“ The heat of the fire acts the stronger upon the bodies to be changed, as the muffle put in the furnace is less; as the said muffle has more and larger segments cut out of it, as the sides of this muffle are thinner; in short, as there are more

vessels placed in the hinder part of the muffle; and on the contrary. In this case, when many of the conditions requisite for the exciting of fire are wanting, then indeed the artificer, with all his skill, will hardly be able to excite the fire to a sufficient degree, in order to perform operations well, in common assay-ovens, even though he uses bellows, and puts coals into the upper door of the furnace. For this reason, I have put the grate almost three inches below the muffle, lest the air, rushing through the ash-hole, should cool the bottom of the muffle, which happens in common assay-ovens; and again, that the smaller coals, almost already consumed, and the ashes, may more easily fall through the interstices of the grate, and the larger coals still fit to keep up the fire be retained. Finally, I have added the above-mentioned funnel, that the blowing of the fire being, by means of it, increased as much as possible, this might at last be carried to the requisite degree; for the fire may always be diminished, but not always be increased at pleasure, without the assistance of a proper apparatus."

FIG 2. This figure represents a furnace called an **ATHANOR**. See **ATHANOR**. This figure and the following description are copied from *Cramer's Art of Assaying*. "This furnace is used for the distillation of acid spirits, for calcinations, cementations, &c. As these operations require a long and constant fire, an athanor is useful, because it can contain as much fresh fuel as will keep up the fire for many hours together, and admits of a different, an accurate, and most constant regimen of the fire.

"Let then, 1st, a small square hollow tower (*a a a a*) be constructed of such stones, [or of bricks made of *Stourbridge clay*, or *Windsor loam*,] as may resist the fire; let the sides of it be six inches thick, and forming a square cavity within, of ten inches on each side (*b b b b*). The height of it is determined according as it is to keep up the fire long, without any addition of new fuel: five or six feet are most commonly sufficient. 2. At the bottom of this tower make an opening (*c*), six inches broad, and as many inches high; hang to it an iron door, being on every side one inch broader than the opening, and such as may shut it very close: for which purpose the external edge of this opening must be excavated all round in such manner, that it may form a groove one inch broad, into which the edges of the door may be received. 3. At the distance of ten inches from the bottom of the tower, put a grate (*d*), made of prismatical, quadrangular iron-bars, one inch thick, and three quarters of an inch distant from each other: let also each of these iron bars be so situated with regard of the tower, that the two opposite acute edges of each may look perpendicularly, one downward, the other upwards, that, by this means, the ashes may easily fall into the ash-hole. 4. Make above this grate an opening circular at top (*e*), six inches high, seven inches broad, that may, as well as the ash-hole. (No. 2,) be open and shut with an iron-door. 5. Adapt to the top of the tower an iron cover (*f*), exceeding the aperture of the tower all around two inches, and having a handle, wherewith it may be easily taken away, and put on again. Thus you are to make the furnace called in *L at n*, *furnus primarius*. 6. Then cut out in any side of the tower, for instance, in the left, an oblong square aperture, going up obliquely towards the outside (*g g*), four inches and a half high, ten inches broad, having its inward inferior

inferior edge, one inch and a half, or two inches above the grate (*d*) ; that by the intervening of this hole, the cavity of this tower may communicate with another immediately to be described. 7. Nearly over-against the same side of the tower, make a cavity with stones, whose inferior part must be a hollow prism, (*b, b, b, b,*) six inches high, twelve inches broad, ending at top in a semi-cylindrical arch (*i, i,*) described by a *radius* of six inches ; that by this means, the height of the whole cavity may be twelve inches in the middle. Let this anterior cavity be totally open, though, when requisite, it is to be shut very close with an iron plate (*k, k,*) whose inward surface is to be constructed in the same manner as is prescribed for the sliding door of the melting furnace, (FIG. 4.) and then luted two inches thick within. Moreover, let there be in the middle of this plate, a round hole, four or five inches in diameter, and let the circumference of this hole have an iron cylindrical border made to it, and prominent within ; that by means of it, the lining of lute within may be supported, and kept from falling down easily. Let a notch one inch broad, and two inches deep, be made in the outward circuit of the aperture of this cavity, to receive the extremity of the plate that shuts the aperture. The hole of this plate, either is shut with a stopple, or serves to pass the neck of the retort through. This plate likewise is fastened with two bolts (*n, n,*), to be put horizontally with iron hooks (*o, o, o, o,*) driven into the wall near the edge of the aperture, so that one bolt may fasten the upper part of the plate, and the other the lower. 8. It is moreover proper, that the square aperture (*g, g,*) through which the fire enters from the tower into the cavity hitherto described (No. 7.), may be shut and opened at pleasure with an iron slider : for if this is not done, an excessive fire, employed sometimes by an unexperienced hand, cannot be so easily checked. For this purpose, let a slit half an inch broad, and eleven inches long, be left in the wall that constitutes the upper part of the cavity (No. 7.), and is contiguous to the tower ; so that it may exceed the length of the square aperture (*g, g,*) a small matter on every side, and reach before and behind into the small groove, going down along the perpendicular sides of the said aperture, (*g, g,*) and retain the iron-slider to be put into it to keep it steady. However, let this iron-slider be, six lines thick, eleven inches broad, and five inches high ; and let a couple of small iron-chains (*p, p,*) be fastened on each side of its upper edge, wherewith the slider may be lifted up and let down again. Therefore, let a couple of strong iron-nails be drove into the contiguous wall of the tower, perpendicularly over those places in which the said small chains are fastened to the iron-slider ; that any of the links of the chains may be suspended on them at pleasure. Moreover, let the upper edge of the slit above described be entirely shut up with stones and cement, leaving only two small holes through which the small chains may be passed. On the left of this cavity (No. 7.), and at the distance of eight inches from the bottom of it, let a square (*q, q, q, q,*) chimney or funnel be erected with *bricks*, three inches and a half in the clear, four foot high, and a small matter convergent upwards, so that the diameter of it at top may be three inches. This funnel must be contrived to be shut closely with an iron-slider, having a handle to it (*r, r,*) which slider must move freely between a double iron square frame fastened in the walls of the funnel, at such a height from the

hearth as shall seem convenient to any artificer. 10. Below this chimney, let a square aperture be made, like the foregoing (No. 6, *g, g,*), leading obliquely up to the bottom of another cylindrical cavity (*u, u, u, u,*) which is eight inches deep, described by a radius of six inches, open at top, and then converging inwardly into a border one inch thick, and six lines broad, designed to support an iron-pot. Likewise, cut in the anterior wall of this cavity, and at the upper part of its mouth, a segment two inches and a half deep, five inches broad, and stooping forward (*v, v,*) to receive the neck of the retort. 11. To this cavity (No. 10.) belongs an iron-pot (*w, w,*) eleven inches broad, and about nine inches deep, which must be encompassed with an iron ring (*x, x,*) one inch broad, and fastened at the distance of one inch and a half from the upper end of the pot. Let a segment (*y*) be likewise cut off the upper edge of this pot, which segment must be four inches and a half deep, and five inches broad: the iron-ring just described must be bent all round the edges of this segment. 12. Over-against the aperture (*t, t,*) which communicates from the first cavity (No. 7.) into the second (No. 10.), let another such aperture (*z*) be made, two inches distant from the bottom of the second cavity (No. 10.) perfectly like the foregoing (*g, g, t, t,*) and communicating obliquely upwards with a third cavity (*1, 1, 1, 1,*), like and equal to the second cylindrical cavity (*u, u, u, u,*); that the fire may pass from the latter into the former. 13. In the hinder part of the wall which makes the aperture just mentioned (*z*), let a chimney like the foregoing (*q, q, q, q,*), and of the same height (*2, 2, 2, 2,*), be erected, which may be shut with a slider like that (*3*). 14. Finally, on the left side of the third cavity let an aperture be made in the same manner (*4*), and like the foregoing ones (*g, g, t, t, z*); more remote however from the bottom of the cavity, without a passage at the other extremity, and communicating only with the cavity of the third chimney (*5, 5, 5,*), which must be erected in the same manner as the two foregoing ones (*q, q, q, q, 2, 2, 2, 2,*). Thus you will have a furnace very proper for a great many operations.

“We are now to speak of the use of the *athanor* just described; and chiefly to mention, to what operations each of its parts serve in particular, and then how the fire may and must be governed in it. 1. You must put at the upper arched door (*e*) of the tower, a semi-cylindrical muffle twelve inches long, which must be introduced through the door: which for this reason must be of the same height and breadth as that door, three quarters of an inch thick, and open behind, being shut there by the hinder part of the *athanor*, as far as which it must reach. For this purpose, a *tile* must be set upon the grate (*d*) to support the muffle. Let also this muffle have small pieces cut out near its basis, as common assay-muffles. You may put under this muffle your cement pots, or such bodies as must be calcined with a long and violent fire; which can be done without a muffle, though not so neatly. 2. In the first chamber (*b, b, b, b, i, i,*) you may make the most violent distillations with an open fire: for retorts or large vessels are introduced into it, after you have taken away the door (*k, k, k,*) and are put either upon the hearth itself of this chamber, or upon a particular support of stone. But you must place these vessels in such manner, that their necks may easily pass through the hole of the door, where  
put



put on again: for which purpose, they chuse a support sometimes higher, sometimes lower, according to the different heights of the vessels. When afterwards the door is put on again, and fastened with both its bolts ( $n, n,$ ), you must close with lute all the chinks which lie open about the neck of the vessel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the vessel a cylindrical segment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminished; lest the recipient, which is always chosen a glass vessel, should split. The recipient, which must be united with the other orifice of the said segment, is supported either by the pavement, or by a certain kind of trivet, the construction of which is such, that it may be set lower or higher by means of three screws. 3. In this same chamber, instead of distillations, you may also make cementations, calcination, &c. in which case the round hole of the iron-plate may be shut and again opened with a stopple, that one may view the inside. 4. The second and third cavities ( $u, u, u, u, 1, 1, 1, 1,$ ) serve chiefly to such operations as are made in baths [or beds] of *sand, ashes, or filings*. For instance, you put into each of these cavities a pot, ( $v, v,$ ) and you stop with thin lute or with *sand*, which must previously be moistened, the slit between the iron-ring ( $x, x,$ ) and the border of the cavity, upon which this ring rests. 5. Besides, you may also make in these two cavities, distillations by a reverberating fire, as well as in the first: only the fire is less violent in these, though sufficient to extract aqua fortis. You then take out the iron-pot ( $v, v,$ ) and inverting it, you put it upon the mouth of the chamber; so that the brim of the pot, being the depth of one inch and a half above the iron-ring ( $x, x,$ ) wherewith this pot is surrounded, may be received within the mouth of the cavity, and so that the segment cut in the pot ( $y$ ) may, together with the segment cut out from the side of the cavity ( $v, v,$ ) form a hole to let the neck of the vessel through. 6. All the *apparatus* being thus ready, you first introduce through the top of the tower ( $b, b, b, b,$ ) a few burning coals; and put upon them some of the unkindled fuel of the fire; that the cavity of the tower may, according as it is thought necessary, be filled either entirely or only in part. Then with all speed you put upon it the iron-cover ( $f$ ), and strew the border of this on the outside with *sand, or ashes*, which you press gently with your hands: for if you should neglect this point, all the fuel contained in the tower would be kindled, and may endanger setting the house on fire.

We shall here annex a few general rules concerning the regimen of the fire in this furnace: for it is hardly necessary to explain all particulars, since practice will easily hint them to such as shall be ever so little acquainted with Chemistry. The fire may be made very strong, in the first chamber, ( $b, b, b, b, i, i,$ ) when the door of the ash-hole ( $c$ ), and the funnel ( $q, q, q, q,$ ) of the chamber is quite open, and when the iron-slider suspended with chains ( $6, p, p,$ ) does not hinder the fire from passing freely from the tower into this cavity. But the closer the funnel is shut, together with the door of the ash-hole, the more the violence of the heat diminishes: and this will be soon effected, if the iron-slider suspended with chains is let down in part: for the fuel contained in the tower burns at least as high as the space between the lower edge of the iron-slider and the grate ( $d$ ). Observe besides, in those operations wherein the

round hole of the door is stoppt with a plug, that when the strongest fire is required, this hole must not be kept long open; because the air rushing violently through it, soon cools the bodies put into the cavity. The operations above-mentioned may be performed in the second and third chamber, in; and at the same time, and with the same fire, as they are in the first chamber; for the fire penetrates from the first cavity into the second, and increases when the funnel (2, 2, 2, 2,) erected on it is opened: but before you do this, the funnel of the first cavity must be shut as much as that of the second is opened. By the same means, you may hinder the fire, which serves for the operations made in the two first cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may also act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one or even both funnels of the other two cavities must be closed: thence it is plain, that you cannot kindle the strongest fire in the third cavity, unless there be one equally strong in the other two; and that, on the contrary, the heat in the third cavity may be rendered less, by closing its funnel; though it be violent in the others. The same is true of the second cavity, with regard to the first. Finally, you cannot make the strongest fire under the muffle placed within the upper door (e) of the tower, unless you have an equal fire in the first cavity, which fire may consequently be increased, by shutting the door quite against the muffle (e), and diminished by opening it; there being mean while an equal heat in the first chamber, and in the following ones. The rest will easily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

- a, The ash-hole door.
- b, The fire place door.
- c, c, c, Registers.
- d, The dome or reverberatory.
- e, The conical funnel.
- f, The retort in the furnace.
- g, The receiver.
- h, h, Iron bars to sustain the retort.

FIG. 4, 5, 6, 7, and 8, represent a MELTING FURNACE. These figures and the following description of this furnace are copied from *Cramer's Art of Assaying Metals*.

"The melting furnace is made of iron-plates, the inner surfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1st. Make an hollow ellipsis, the focus's 12 inches asunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may assume the figure. (Fig. 4.). 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter; and directly opposite (c, c.). 3dly, Then fasten two flat iron-rings (d), almost one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inside of it with small iron-hooks, jutting out about six lines, and three or four inches distant from each other. These, together with the rings just mentioned, serve to fasten the lute. Thus will the body of the furnace be made: only you must add

add at the outside two iron-handles (*e, e,*) to be rivetted on each side of it, that it may be taken hold of and moved. 4thly, Then make the cover of the furnace, which may be formed like the part cut off from the ellipsis (See *Fig. 5,*). Let this have an opening (*b*) made in it, four inches high, five inches broad at bottom, and four inches at the top; and adapt to this an iron door hung on hinges to shut it close, and having at the inside a border fastened to it, answering exactly to the circumference of the door, and as prominent inwardly as the thickness of the lute to be applied to it requires: for the same purpose, let small iron-hooks be fastened to the inside of the door, which is intercepted by the said border. And lest this cover should be burnt within by the force of fire, you must cover the inside of it over with the same lute mentioned before for the assay-oven: therefore it must be likewise furnished with a ring and iron-hooks to fasten the lute; as was said before, when we spoke of the body of this furnace. Besides this, you must fasten two iron-handles (*Fig. 5, c, c,*) on the outside of this cover. Then a round hole must be made in the top of it, being three inches in diameter, prolonged into a hollow tube (*d*), almost cylindrical, and a few inches high, upon which the iron-funnel described may, in case of necessity, be put after the manner mentioned in the same place where we spoke of the assay-oven. 5thly, After this, the lining of both the body and cover of the furnace within is made in the same manner above-described. Moreover, you must make for this furnace two moveable bottoms, *viz.* one to receive the ashes, and admit the air; the other to serve for reductions. The first is made with an iron-plate, formed into a hollow cylinder, open at top, and to be shut at bottom with an orbicular iron-plate, as with a basis, five inches high, and of such a diameter, as that it may receive the inferior orifice of the body of the furnace (*Fig. 4,*) the depth of half an inch (See *Fig. 6,*): therefore let an iron-ring (*c*) half an inch broad, be fastened on the inside of the said bottom, and at the distance of half an inch from its upper border, to support the body of the furnace put into it. Again, let this bottom have a square door, four inches high, and as many inches broad, that may be shut closely with a door hung on hinges, that you may by means of it increase or diminish the draught of the air, and thus govern the fire at pleasure. Then, on the left side of this door, and at about half the height of this bottom part, let a round hole (*d*) be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so that it may be of the height of seven inches. Likewise let it have round it a like iron-ring below its upper border, to support the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high (*Fig. 7. c,*) be cut out just below the ring in the side of this bottom part; then let another round hole be made in the left side of this first hole, fit to admit the pipe of the bellows (*d*). Further, let another round hole like the foregoing (*e*) be made on the right, and at the distance of one inch from the bottom: then let the whole inside of this bottom-part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that represented by the line (*f, g, b,*). The matter of which this is made

is common lute pulverised, passed through a sieve, and mixed with such a quantity of dust of charcoal, sifted in the same manner, so that the mixture being moistened and pressed down, may at least be lightly coherent. Of this matter pressed on the bottom of the bottom-part a bed is made, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth, after the manner mentioned before when we spoke of large ash-vessels or tests.

This furnace is chiefly fit for fusions, which may be made in it with and without vessels. When you are to melt with a vessel, put the body of the furnace (*Fig. 4.*) upon the first bottom (*Fig. 6.*), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace (*Fig. 4. c, c*); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth every where, warmed, and perfectly dry: otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapors coming out of it in the operations. Let the height and width of this *stone* be a small matter broader and higher than the bottom of the crucible or pot to be set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then put upon this *tile* the vessel containing the matter to be melted, and surround it immediately with coals on every side, which must be ranged according to the method prescribed before, in our description of the assay-furnace: then you govern the fire, by opening and shutting the door of the ash-hole (*Fig. 6. b*): you excite it by putting the cover (*Fig. 5.*) upon the body of the furnace; and if, besides, you put a funnel upon the cylindrical mouth (*d*) of this cover, the melting fire becomes still more violent: but if you moreover introduce the bellows through the hole of the bottom part (*Fig. 6. d*); and the joint of the furnace with the bottom part, and the door of the ash-hole, unless it can be shut very close, being exactly stoped with thin lute [*or Windsor loam*], the fire thus excited by the blast of the bellows is carried to the highest degree, and far surpasses that which may be made in a Smith's forge. Another advantage of this method is, that the vessels are not so easily broken, because the blowing of the bellows cannot affect them immediately, and because a fire perfectly equal is excited on every side. One may easily examine with this apparatus, how *stones* are affected by the violence of the fire only. Now, if you have a mind to perform any operation without a vessel, and with a naked fire; for instance, to melt and reduce the *calxes* or *scorias* of copper, tin, lead, and iron, or the ores of these metals; the body of the furnace must be put upon the other pedestal, having a bed in it (*Fig. 7.*). However, you must, before this, open with a knife the oblong hole (*c*), and the round one (*d*) of this bottom part, which are stopped with the lute sticking to the inside: then you apply at the round hole (*d*) on the left side of the bellows, in such manner that the nozzle of it, being directed obliquely downwards, may blow strongly against the bed (*f, g, b*): by this means, all the ashes that fall into the bed are blown away, and the strength of the fire determined to such a degree, that all the melted bodies that fall into the said bed remain in their state of fusion; and were it otherwise, the melted bodies would immediately wax cold, and adhere

adhere in grains to the bed, whereas they ought to have melted into one *regulus*. The oblong hole in the fore-part of this bottom-part (*c*) serves to discover, by means of a poker, whether the matter in the bed be melted or not : it serves likewise to take away through it whatever might stop the bellows, and in some cases to take away the *scoria* : then you put first coals into the furnace one span high, and blow them well with the bellows, to make them burn, that the bed may be very hot before the matter to be melted is put into it ; for if this is not previously done, the melted mass seldom runs into a *regulus*, but remains dispersed among the *scorias*, which soon grow hard. The bed being well heated, and fresh coals added to the fire, put into it such quantity of the matter to be melted as cannot hinder the fire from being carried to the requisite degree ; which cannot be determined otherwise than by experience : again, put fresh coals, and upon them another quantity of the matter to be melted ; they may be, like *strata*, one upon another : but if the mass, once melted, could not long sustain the strength of the fire, or if you had a mind to melt a greater quantity of matter than what can be contained in the bed, you must open the round lower hole (*Fig. 7. e*), that you may make a channel passing from that hole through the lute, and reaching to the small cavity at the bottom of the bed (*g*) : to this hole, at the outside, apply an earthen dish like the bed within, or any other proper recipient, furrounded with burning coals, into which the matter melted, running from the bed through the hole (*Fig. 7. e*), may be collected, as is represented by *Fig. 8*.

**FIG. 9.** A transverse section of a FURNACE in which SULPHUR is obtained by distillation from pyrites. In this furnace are placed ten or twelve tubes, one of which is represented in this section (*7*), lying across the whole breadth of the furnace. These tubes are open at both ends. At the larger end, the mineral, from which the sulphur is to be distilled, is to be introduced ; and then the opening is to be closed with an earthen stopper. The smaller end opens into a cast-iron receiver (*8*), which receives the sulphur that is distilled or eliquated. To prevent the crude mineral from passing into the receiver, a star-like piece of baked earth is placed in the neck or smaller end of the tube, along with the sulphur. Each furnace contains ten or twelve such tubes. The length of the whole furnace is therefore evidently much greater than its breadth. The tubes are about four feet long, somewhat of a conical form, six or eight inches wide at their larger end, and three quarters of an inch at their smaller end.

- 1 The walls of the long sides of the furnace.
2. The ash-hole.
3. The grate made of bricks.
4. The fire-place.
5. The passage for the flame to the upper part of the furnace.
6. The two walls of the long sides of the furnace which support the tubes.
7. A tube placed across the furnace.
8. A square cast-iron receiver.
9. Two holes in the roof of the furnace through which the smoke escapes.

There are generally ten or twelve such holes in different parts of the roof, some of which are occasionally closed. See a further description of this

*this furnace, and of the operation of extracting sulphur, at the article SMELTING of ORES.*

FIG. 10. This figure represents a transverse section of a FURNACE for PURIFYING SULPHUR by DISTILLATION. See SMELTING of ORES.

1. The foundation of the wall sunk under ground.
2. The side-wall.
3. The back-wall.
4. The ash-hole.
5. The grate.
6. The fire-place.
7. Two holes through which the smoke escapes.
8. The inner chamber of the furnace.
9. An iron cucurbit or pot.
10. A neck made of earthen-ware.
11. The vessel called the fore-runner.
12. A receiver.
13. A banquette or step raised to support the fore-runner. In this furnace, which is of an oblong shape, generally five or six such sets of distilling vessels are placed on each side.

FIG. 11. Represents a quantity of ore piled up to be roasted.

1. Two sides or faces of the pile. All the sides of it are covered with small ore.
2. The upper part of the pile, where holes or cavities are seen in which the sulphur of the ore is collected.
3. An opening where part of the pile has fallen down, and in which the sulphur is seen dropping down.
4. A plank to keep off the wind. See SMELTING of ORES.

FIG. 12. A Section of the above Pile.

1. The wood to make the fire.
2. Some charcoal for the kindling of the fire.
3. A channel formed by a wooden tube or pipe.
4. The large lumps of ore.
5. Small ore.
6. Finer ore, or dust of ore.
7. The substance called *vitriol*, that is, a half roasted ore powdered.

FIG. 13. Represents a longitudinal section of the FURNACE at RAMMELSBERG. See a description of this furnace at the article SMELTING of ORES of SILVER.

1. Foundation of the masonry in the ground.
2. A part of the back wall.
3. The tuyere.
4. Channels to carry off moisture.
5. The covering stone of these channels.
6. A bed of scoria.
7. The case or casse made of bricks.
8. A bed of clay.
9. A bed of sifted ore and substance called *vitriol*.
10. The charcoal which is thrown into the casse previous to the filling of the furnace with ore and fuel.











